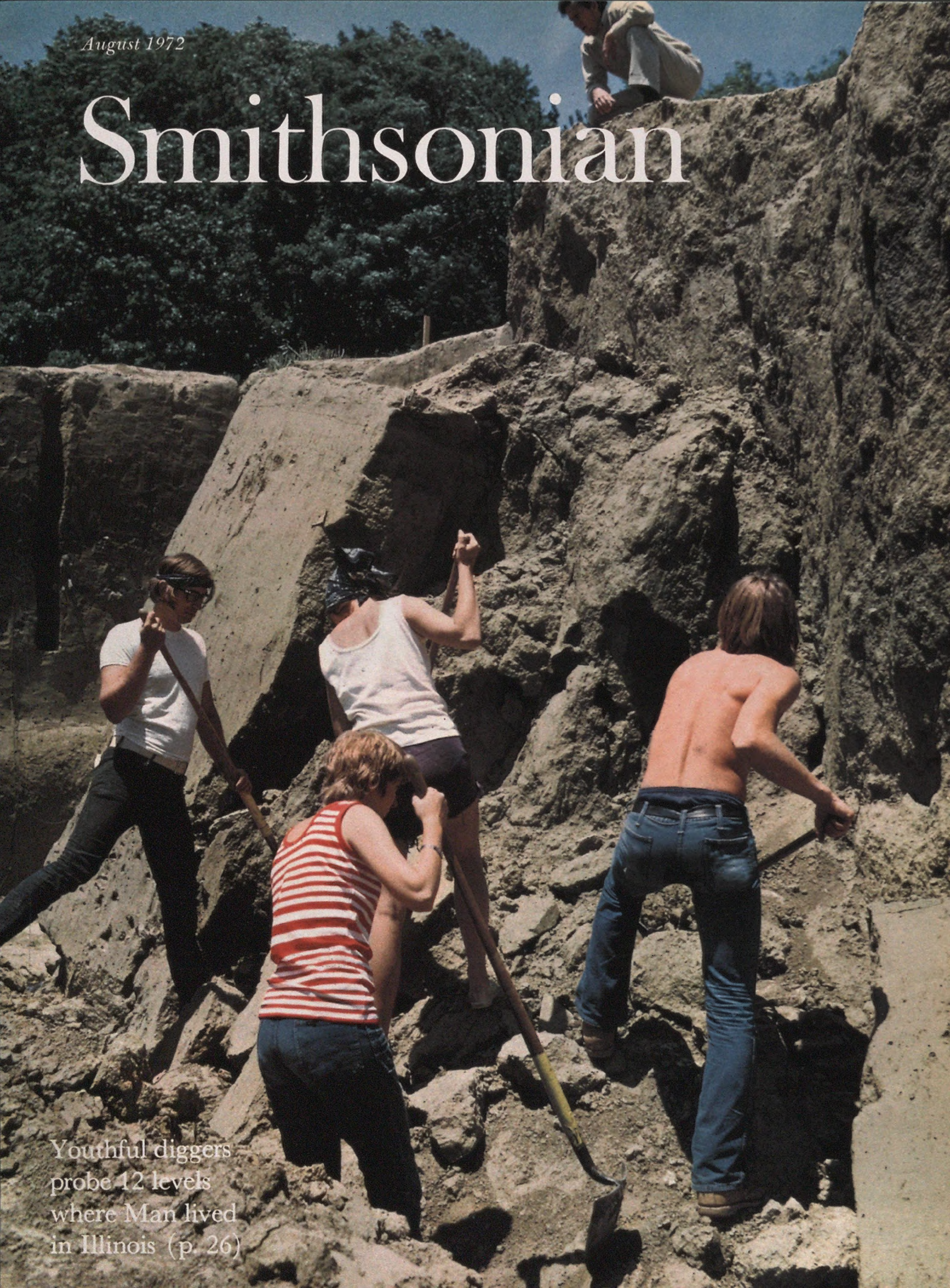
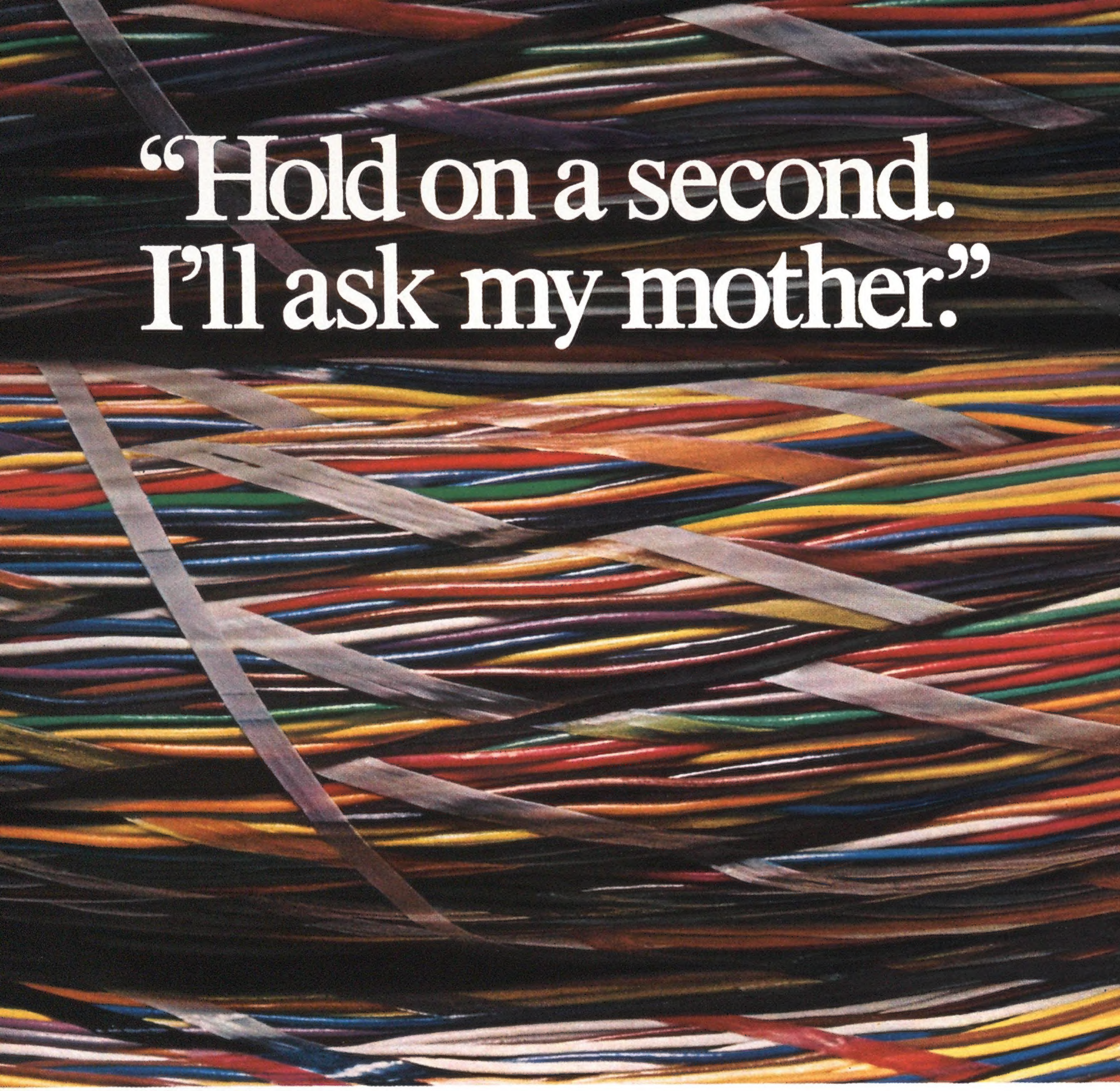
August 1972

Smithsonian



Youthful diggers probe 12 levels where Man lived in Illinois (p. 26)



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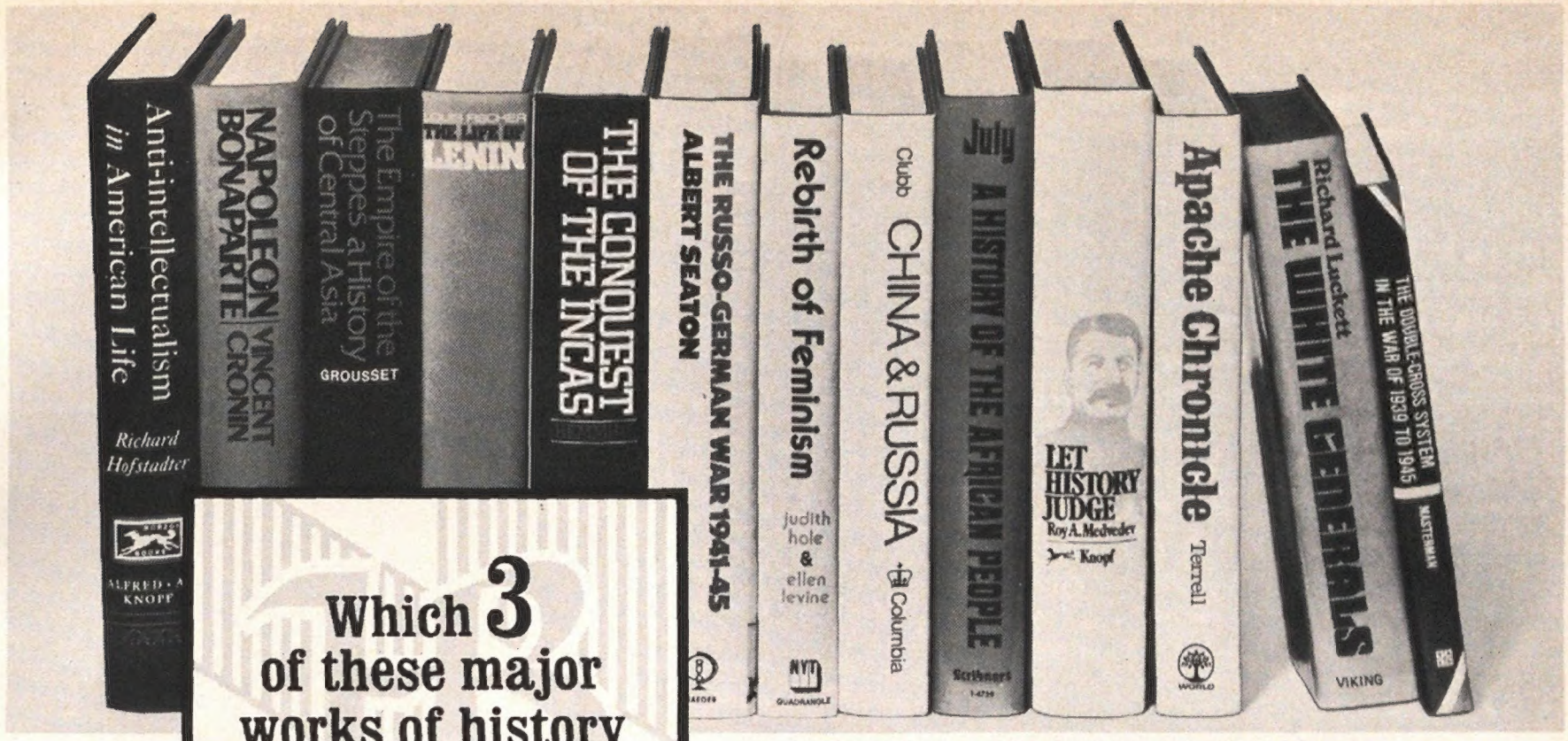

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Secretary Ripley's comments

The view from the castle

Despite stultifying rules, instant experts and minor gurus and oracles, the Stockholm conference was surprisingly productive

To be chosen as a U.S. Delegate to the United Nations Conference on the Human Environment was of course an honor for me. But as the months passed and rumors flew (Would the states of Eastern Europe attend or not? Would there be a hostile confrontation between the rich and the poor nations?), I felt that the tireless efforts of Maurice F. Strong, the Canadian who was appointed Secretary General for the Conference, would all be in vain.

One could well have wondered what might come from such a meeting. The rules of all such conferences are invariably designed to stultify initiative, smother intelligence and homogenize every phrase. Each delegation is cushioned by "expert" assistants who lean over the delegates' shoulders and prime them with what to say and how to vote.

Five years ago, however, such a conference would have been impossible. Ten years ago the word "ecology" was just coming into circulation. Now it has arrived, bandied about as a political issue. The term is used with confident authority by economists, politicians, lawyers and others whose previous ecological experience was confined to crabgrass, the golf course or a day at the beach.

Furthermore, at any such conference, and especially this one, hangers-on of all sorts appear. Being highly sophisticated, Mr. Strong and our Swedish hosts organized a concurrent conference of non-governmental organizations. The NGOs, as they were called, ranged the gamut from highly respected UNESCO-affiliated organizations to minor gurus and oracles. In between were young communal groups like the Pig Farm, various church affiliates and earnest instant ecologists.

When the Conference began, the NGOs were hurt by the mole-like persistence with which the official delegations stuck to their plenary and committee assignments. The delegates, being mostly professional delegates and unfamiliar with environmental issues, tended to be gun-shy of the NGOs, afraid of betraying themselves into a commitment. Everyone watched the People's Republic of China, which failed to vote on anything and thus appeared timid on environmental questions and uninterested in anything but politics.

But in the end, and in perspective, the Conference came out extraordinarily well. One hundred and twelve nations agreed to recommend that the United Nations establish new environmental machinery perhaps reporting to the Economic and Social Council (ECOSOC). It would operate by means of an Environment Fund to which many of the richer nations have already pledged support, including a $40 million commitment from the United States. The new organization would function in the areas of global monitoring of pollution levels, population studies, international waterways consultation and marine studies. Also, the Conference agreed to a moratorium on whaling, called for a free exchange of scientific information and even expressed hope for a prompt agreement on banning nuclear weapons. All this is no small accomplishment.

Another conference should be held in perhaps five years to review progress. For by that time, practically everyone will have come to realize what so few have in the past: that at present rates of environmental abuse, we are all willing our own destruction.

S. Dillon Ripley

Short-lived phenomena

Progress among the knuckle-walkers, a new kind of plant, the bugging of fish and an invasion by Canada

Early in June the Center for Short-lived Phenomena received word that Canadians were invading northeastern Minnesota—in this instance, Canadian lynx. (A similar invasion occurred ten years earlier, with one lynx reaching as far south as Iowa and 100 shot on U.S. soil.)

By the end of June there were more than 20 reports of lynx being run down by motorists or shot, according to L. David Mech, a wolf specialist with the U.S. Fish and Wildlife Service in Minneapolis. Three were hit by cars in one day in April; most of the other fatalities occurred in May and June.

One lynx reached Duluth, spending an afternoon sitting in someone's yard until it was dispatched. Another reached the suburbs of the Twin Cities, which, Mech says, is "certainly not lynx habitat." In one case, Mech reported, a female with four kittens the size of muskrats was seen several days in a row and was suspected of snatching the household pets that had been disappearing from the neighborhood. The mother subsequently was shot and in late June the fate of her kittens was unknown.

Apparently the lynx were coming down from Ontario as a result of a shortage there of snowshoe rabbits, the lynx's main prey, in one of those up-and-down cases of population dynamics that have long fascinated students of cycles.

Taller but lighter than a bobcat, a lynx is an alarming thing to find in your backyard, hence the shooting (there is no longer a bounty on lynx in Minnesota). According to Mech, the intruders are usually seen "looking bewildered" in their unfamiliar surroundings, which may explain their vulnerability to automobile traffic. In the course of his normal wolf-trapping activities, Mech snared two presumably bewildered lynx and, not missing a chance at some research, tagged one and attached a small radio transmitter to it so that he could track its wanderings until it, too, meets the fate of the international aggressor.

Did we ever really swing?

Some Victorians were outraged at the notion that their ancestors might be apes, perhaps because, among other reasons, the activity of swinging through the trees is hardly dignified. Nowadays nearly everyone has gotten over being embarrassed about having apes for relatives, but whether or not our direct progenitors actually did swing in trees remains moot.

Some scholars have looked at the wrist bones of the living apes as well as an ancestral form called *Dryopithecus* (which lived 18 million years ago in Africa) and found them all nicely adapted for tree-swinging or, as it is called, brachiation.

But recently two Yale scholars, Glenn C. Conroy and John G. Fleagle, reexamined the subject and decided that such is not the case at all. The stiff wrist of that archetypal brachiator, the gibbon, is admirably suited to "ricochetal arm-swinging" but, they concluded, the more flexible wrists of chimpanzees, gorillas and *Dryopithecus* are clearly adaptations for knuckle-walking, not brachiation. Since

Felix, fist-walking at Brookfield zoo

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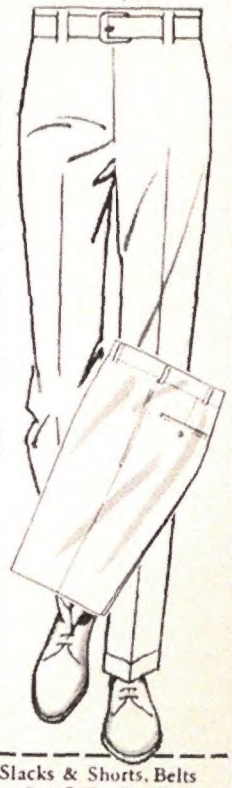

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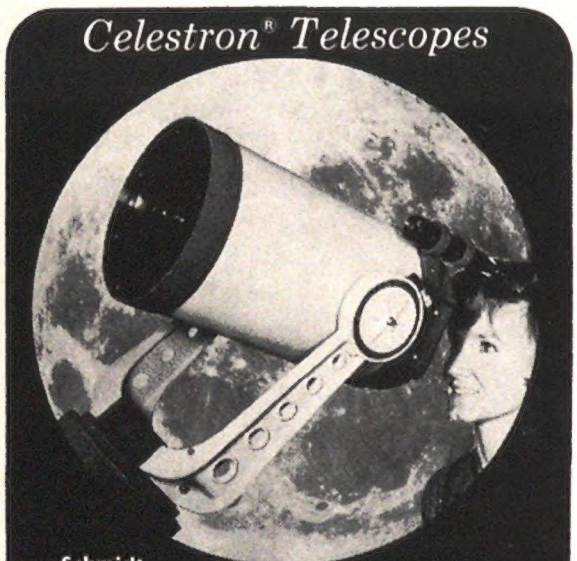

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we humans are certainly closer to the chimps and gorillas than we are to gibbons, the implications seem to be that when our progenitor headed down the path toward Man it was already a knuckle-walker.

Thus, one might say, when one group of apes went off idly swinging through the trees, the main group had already knuckled down to the serious business of becoming human.

Those who find that a neat and (for whatever reason) satisfying hypothesis should not relax. The waters have already been muddied by a fat 16-year-old orangutan named Felix.

Felix has been carefully studied, videotaped and photographed by two scientists of the University of Chicago, Russell Tuttle and Benjamin B. Beck. Until 1967, they report in *Nature,* orangutans were considered knuckle-walkers, along with their African cousins; then they were accused of being altogether incapable of knuckle-walking. Now, it seems clear from Felix's activities, orangs can engage in what the two scientists call "fist-walking." This is a kind of semi-knuckle-walk wherein some but not all the body's weight is borne on the knuckles. They compare it to the posture seen in "certain public speakers and football linesmen."

On the other hand, orangutans are still widely accepted as being highly advanced tree-climbers and arm-swingers (though less expert than gibbons). So, the two Chicagoans suggest, it may have been the capacity to brachiate that predisposed the ancestors of African apes to knuckle-walking. Meaning, it seems, tree-swinging may have been a more recent part of our heritage than some people think.

The debate will presumably go on. If the outcome seems of little importance (which it might unless you happen to be a trapeze artist seeking self-confidence), remember that only we, and not even Felix, could ask the question.

With regards to Nature

SMITHSONIAN notes—with a mixture of envy, respect and occasional bewilderment—the number of correspondents reporting to *Nature,* the venerable and obviously useful British magazine of science. Of course SMITHSONIAN has access to experts in all these fields, but in any issue of *Nature* you might find bulletins filed by anonymous reporters such as the Molecular Biology Correspondent, the Geomagnetism Correspondent, the Marine Vertebrate Correspondent, the Paleoanthropology Correspondent, the Medical Virology Correspondent or the Cosmology Correspondent.

Some of *Nature*'s correspondents are apparently geographic in nature, such as the Washington Correspondent, the Soviet Union Correspondent and, hard as it is to imagine, the Magnetosphere Correspondent.

Also, many bulletins are signed merely, and altogether anonymously, by A Correspondent, who seems to be the person assigned to cover a host of fields each too small to have its own Correspondent. For example, Myriapodology.

A new plant for plastic deer

A botanizing Smithsonian Associate, Mr. Gordon Hyatt of New York, recently experienced that rare thrill of discovering a new species of plant. Driving along the Gulf Coast of Florida he spied a remarkable "yucca" (shown below) with tulip-shaped flowers growing from the tips of its sharp-pointed leaves.

New "species" spreads in Florida

But the thrill was short-lived. Upon closer examination, the flowers turned out to be the individual segments from common polystyrene egg cartons, cut out by a local horticulturalist and skewed onto the plant. According to Mr. Hyatt, the

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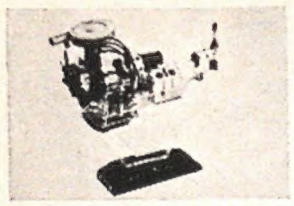

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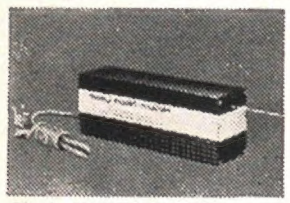

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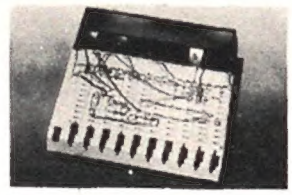

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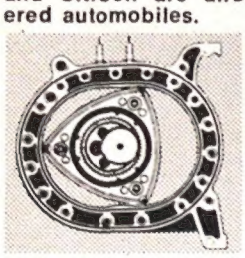

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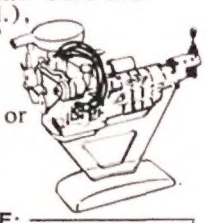

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variety is spreading rapidly, "much to the frustration of honeybees, hummingbirds and sapsuckers," in which category Mr. Hyatt now considers himself included.

Voyeurism in Moco-moco Creek

Elsewhere in this issue (page 56) there is news of the remarkably complex kinds of communication which lobsters and some other marine creatures enjoy by means of chemical senses. But they have nothing on some of the inhabitants of Moco-moco Creek in the South American country of Guyana. There, in the spring, an underwater electric show takes place each night and Carl Hopkins of Rockefeller University is one of the few humans privileged to have witnessed it.

In Moco-moco Creek there are 11 nocturnally active species of gymnotid fish possessed of "electric organs" for transmitting and receiving the electrical information with which they fill the stream's rapidly moving waters. Armed with electrical equipment of his own, Dr. Hopkins eavesdropped on this confusion of messages. Seven of the species emit short pulses of variable frequency; the other four use longer bursts of stable frequency, Dr. Hopkins writes in *Science* magazine.

One of the latter four species, *Sternopygus macrurus,* received most of Hopkins' attention. In the breeding season, he found, the males of this species lurk in well-protected hiding places and occasionally their electrical outbursts are characterized by brief rises in frequency and short interruptions.

Why? Dr. Hopkins recorded no such signals when another species of gymnotid swam by, or when another male *Sternopygus* passed. But if a female *Sternopygus* swam into the vicinity, emitting her own characteristic signals, the male would announce his whereabouts with a sudden case of electronic hiccups.

Headache for caviar-lovers

The Caspian Sea is in trouble and along with it the sturgeon fry who feed there. The water level has been dropping since the mid-1930s and the salinity increasing. Industrial growth along the Volga and Ural rivers has pumped industrial wastes and sewage into the sea. Offshore oil drilling (mostly on the western side) has added to the problem and even the Soviet fishing fleet has been polluting the very

sturgeon feeding grounds it survives on. The Caspian is "a major source of concern to Soviet ecologists," says the *Marine Pollution Bulletin*. Pointing to antipollution messages in the current five-year plan, the Soviets are calling for 400 new purification plants on the Volga and hope to equip the Soviet fleet with pollution collection devices. Also, for the long term, they are building canals that will divert fresh water into the Caspian from Siberian rivers now flowing into the Arctic. A new nonmigratory sturgeon has been developed (though it is not breeding well in captivity).

While the Caspian is receiving the ecological "attention it so vitally deserves," as the *Bulletin* puts it, it is also receiving some other, ecologically ominous attentions. The same five-year plan that summons the Soviets to antipollution efforts, also calls for more oil production. Now Soviet geologists have announced that they have struck oil on the Caspian's eastern side and a mammoth oil port is planned.

Sounds familiar, doesn't it?

While the human contribution of mercury to the world's oceans is trivial compared to natural amounts, such is not the case for copper, a heavy metal that can be highly toxic to marine organisms. Based on studies made off the Los Angeles coast, a California chemist, J. N. Galloway, estimates that man's contribution of copper from such sources as municipal waste and mining operations is about the same as the amounts reaching the oceans from such natural processes as weathering of rocks. Such a ratio, he warns, constitutes a serious problem.

For the first three months of 1972, the birth rate in the United States fell nearly to the level required for zero population growth. The drop may have been for temporary reasons, such as the economy, but even if the current rate (15.8 births per thousand) were to be maintained indefinitely, it would be 40 years before the population stopped growing.

In what might well be a case of biased reporting, a scientist named Fox has recently published a book entitled *Integrative Development of Brain and Behavior in the Dog*.

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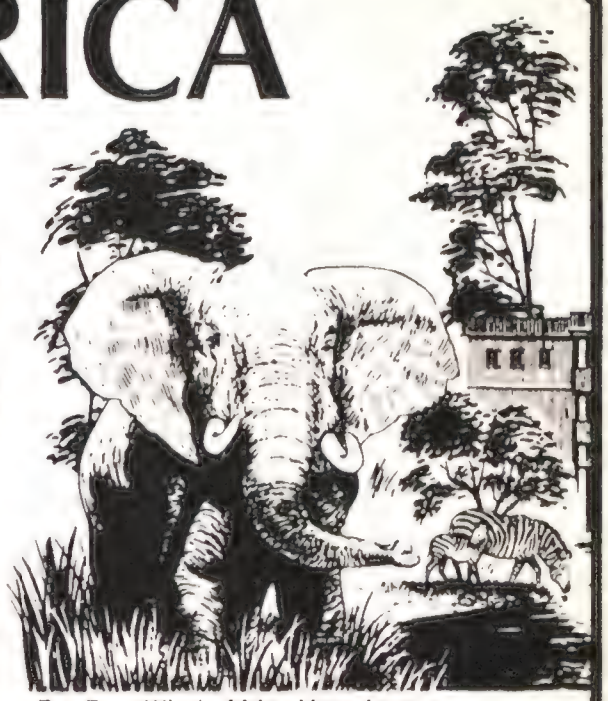

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Letters to the Editor

Killer whales

Dear Sir: By your very act of publishing in the June issue Jacques-Yves Cousteau's article on the killer whale, you condone his and others' relentless efforts to harass marine mammals and mislead the public. Instead of an article by Cousteau on the killer whales, you might, instead, have turned to a bona fide cetacean expert, such as Dr. Victor B. Scheffer.

The fact that Louis Prézelin and friends were going to teach the killer to sing is ridiculous. I feel as do many other marine mammalogists that Cousteau is presenting an image of marine mammals to the public that may prove detrimental to the animals.

Terrell C. Newby
University of Washington
Seattle, Washington

Whatever differences marine scientists may have with Cousteau, few would argue that millions of people in the general public have become familiar with marine animals through his undersea adventure films.

Cousteau writes that he is "always touched and saddened by the sight of an animal in captivity," but he feels there is much to be learned by observing the killer whales in marine zoos.

Dr. Scheffer, who apparently agrees with Cousteau, had this to say in an article: "A spin-off result of holding killer whales in captivity is new light on their husbandry, or care. . . . And towering above the scientific value of captive killer whales is the knowledge that millions of people are now being led to a new experience—a combination of entertainment and education—that surely leaves them with a warmer and closer feeling for animals." Ed.

Antarctic explorers

Dear Sir: We hope in the future you will reject articles such as "Explorer and wife in the Antarctic" that glorify trophy hunting.

Alice Herrington
President,
Friends of Animals, Inc.
New York City

We have been accused of being anti-hunter as well, but we draw the line between legally and illegally killed animals. Every museum of natural history in the country uses examples of taxidermy when the specimens were killed legally, as was the case with the Ronnes' animals.—Ed.

Presidential losers

Dear Sir: I strongly disagree with the treatment given Colonel Aaron Burr in your article by Gene Farmer, "In an election year it's useful to remember might-have-beens."

Colonel Burr did not oppose Jefferson in the election of 1800. They were running mates.

If there had been no Burr-Hamilton duel, Colonel Burr would have been remembered for other, and more important, things. Examples: his vote as President of the Senate upon the repeal of the Federal Judiciary Act and his impartial conduct of the impeachment trial of Associate Justice Samuel Chase.

His expedition to the West was no "harebrained scheme." It was similar to other expeditions favored by Mr. Jefferson at the time—but Jefferson was determined to ruin Burr's chances for any possible return to political power.

Samuel Engle Burr jr.
President General,
The Aaron Burr Association
Linden, Virginia

It is inaccurate to call Burr a running mate of Jefferson. Until the ratification of the 12th Amendment in 1804, the Vice President was the man who came in second in the Presidential race.

Even if other expeditions to the West were favored, that does not condone Burr's actions. Burr's plans assumed the possibility of war with Spain; unfortunately, he did not know that his fellow schemer, General Wilkinson, was on the Spanish payroll. Wilkinson, who had an eye out for his own safety, sent the dispatches to Washington which caused Burr to be tried for treason. His "treason" was not overt, but the incident ended his public career. Ed.

Chandigarh

Dear Sir: Your article on what went wrong at Chandigarh reminded me of two incidents that happened long ago.

In 1912, my mother loaded me into the back seat of our Pratt-Elkart automobile. After she stopped to pick up her sister, we drove out on a country road to a farmhouse wake. The farmyard gate was badly in need of repair, and my mother observed, "With all the boys they have here, it looks like they would fix that gate." My aunt's response was, "Look at all the beautiful white chickens Mrs. Smith has."

On the trip back we passed another farmhouse, and my mother exclaimed, "Their house sure needs painting." My aunt replied, "Did you see all the geraniums Mrs. Jones had in her windows?" Two sisters were looking at the same objects with different points of view, but who can say either's opinion was in error?

The most efficient government cannot legislate happiness, nor can the most able architects present acceptable plans that go beyond the basic amenities that all people enjoy.

Roland H. Holl
Sadorus, Illinois

Illegal art

Dear Sir: I highly approve of Secretary Ripley's comments in your July issue on vandalism and theft in museums, but I would appreciate a correction of a statement attributed to me in your March issue in the article, "The billion-dollar illegal art traffic—how it works and how to stop it."

I find that I was quoted as being opposed to the UNESCO Draft Convention. I am not opposed; in fact, I strongly favor it. However, as had been pointed out by the President of the United States in his letter of transmittal to the U.S. Senate, some sections of the treaty would for many countries be difficult or impossible to administer.

In connection with the tremendous attendance at museums, your abbreviated statement may be misleading. What I wrote was: "The United States is com-

posed of peoples of many ethnic origins, people who take pride in their cultural heritage. It is reasonable that these people would wish to see these cultures, where possible, represented in their local museums."

C. C. Cunningham
Director,
The Art Institute of Chicago
Chicago, Illinois

Short-lived phenomena

Dear Sir: In connection with your item on the *jökulhlaup* in Iceland, I would like to give you the latest information and also correct the spelling. In my telephoned message to the Center for Short-lived Phenomena, the final "p" was misunderstood and changed to a "t."

The *jökulhlaup,* which originated at Grímsvötn, was probably volcanoglacial in origin. Strong sulfurous vapors had been reported just prior to and during the *hlaup* in the vicinity of the ice cap Vatnajökull. A considerable subsidence of the accumulated ice within the Grímsvötn caldera was later observed.

Jules D. Friedman
Geological Survey
U.S. Department of the Interior
Washington, D.C.

Ice-dammed lakes (center) are near the point where flood waters emerged from the Icelandic *jökulhlaup* in March.

View from the castle

Dear Sir: In Secretary Ripley's comments on the problems of growth in universities and museums, I object to this statement: "Unfortunately, most administrators consult economists, engineering planners and other purveyors of soft science rather than physicists or biologists." Certainly physicists and biologists have much to contribute and should be consulted. Economists do also, however, and I contend that they are seldom consulted and that administrators often act foolishly because they fail to consult economists or other qualified persons.

George Kronbach
Research Economist,
University of Tennessee
Knoxville, Tennessee

Milton, the musk-ox

Dear Sir: Thank you for including the pictures of Milton in your article on the pandas. I didn't meet Matilda, but I did have the privilege of meeting Milton.

It happened one morning when I and three other University of California "zoogeography" students arrived at the San Francisco zoo's main gate too early, and an employee admitted us into the children's zoo. As we walked in, out came to meet us a small, black furry animal with shiny eyes, advancing with a definite air of "How *nice* of you to come!" We petted him and admired his long, thick fur—and regretted having to leave for our class. That was Milton.

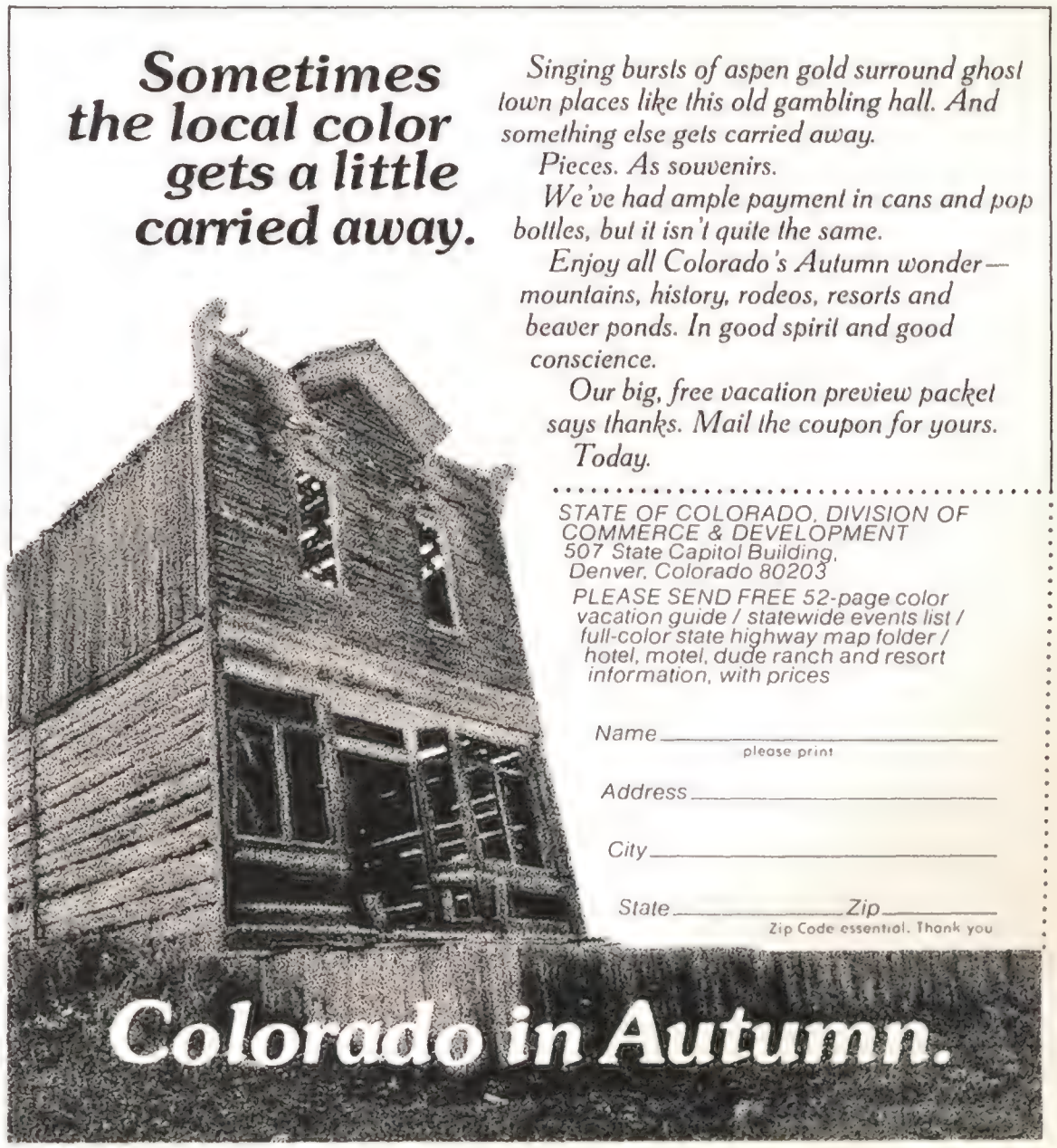
The zoo now has two new baby musk-oxen and they are all right, I'm sure, but they are not Milton. I do hope Milton and Matilda are happy in their new home in China.

Elizabeth J. Norton
San Francisco, California

Carrie Dormon

Dear Sir: In connection with your article in February, "The green world of Carrie Dormon," I have just learned from the campus newspaper of Northwestern State University in Natchitoches that Miss Dormon's writings, drawings and personal effects have been given to the university library's Cammie G. Henry Louisiana Room. This is of special interest to me, since I am a student there, but I thought your readers, who might be traveling in the area, would like to know about the Dormon collection.

Allen H. Aymond jr.
Alexandria, Louisiana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Photographed in the far-ultraviolet portion
of the spectrum by a camera on the moon, the Earth
is almost enveloped in a huge cloud of hydrogen.

By Wilson Clark

Hydrogen may emerge as the master fuel to power a clean-air future

Experiments have shown that this element, superabundant but overlooked, could rid automobiles of most of their pollutants

Hydrogen is the most abundant stuff of the Universe, but the average American thinks of it only in terms of a high school physics experiment. Yet in the last few years a determined and scattered band of inventors, chemists, businessmen, scientists and citizens have found a compelling use for this lightest of all elements. They have identified simple hydrogen, which can be made from ordinary water, as the most flexible fuel Man has yet learned to harness.

In addition, they have tackled one of the single greatest enemies of the world environment—the automobile engine—and have converted it into a machine capable in some cases of expelling water vapor as its single emission.

In 1969 more than 90 million tons of assorted pollutants were emitted in the United States by cars, one-third of total air pollutants.

With the passage of the Clean Air Act, as amended in 1970, stringent federal standards have been set for the emissions of major pollutants arising from the combustion of gasoline in automobile engines: primarily hydrocarbons, carbon monoxide and oxides of nitrogen (NOx). To enforce the new standards, the Environmental Protection Agency's strategy is to compel automobile manufacturers to place as many anti-pollution devices as possible on the mass-produced car, and the news is full of the manufacturers' difficulties as they try to meet EPA's timetables.

The emission-control systems for cars in the next two or three years will cost anywhere from $300 to $700. You can either pay the stiff penalty for "cleaning up" the internal-combustion engine, give up your car, or find a different kind of automobile. Many have been proposed and built experimentally, including rotary turbine cars and hybrids.

However, very little attention has been paid to changing the *fuel* instead of the engine. It is, after all, the fuel—gasoline—not the engine, that is dirty. So far, experience with fuels other than gasoline has been primarily confined to cars using natural gas or propane, which burn without the mass of noxious combustion by-products identified with gasoline. To burn propane or natural gas, a car needs a new fuel tank and modifications of the engine, particularly the carburetor. The cost of conversion is about $300.

According to a recent EPA report, "Enough experience has now been accumulated with gaseous fuel vehicles to demonstrate that under closely controlled fleet-operation, the fuels can be used safely." EPA concludes that a "significant reduction in hydrocarbons and carbon monoxide can be expected," and "some reduction in oxides of nitrogen." Fuel costs are lower. The only major operating drawbacks to natural gas are a 15 percent reduction in engine horsepower at high speeds and a more limited operating range.

Given such a rosy prospect, the use of gaseous-fueled vehicles might increase rapidly—except for one problem. The supply of the key ingredient—the fuel—is dwindling. Severe shortages of natural gas exist in the United States and imports are necessary. Propane, a by-product of natural gas processing and petroleum refining, is next. Even oil supplies, ultimately, are finite.

Fortunately, a substitute fuel is available, though

Mr. Clark, whose article on solar power appeared in last November's SMITHSONIAN, *is now writing a book on alternative energy sources, for Doubleday.*

The problem: Exhaust builds up dramatically as this car accelerates in Ames, Iowa. Ninety million motor

few people know of it. Yet hydrogen put the first man on the moon. Engines have been powered with it on a small scale in this country since the early 1920s. It contains more than twice the energy per pound of gasoline but no hydrocarbons. It burns well in almost any vehicle engine and it would not require a complete retooling in Detroit.

Most current experiments with hydrogen engines are relatively simple, if ingenious, adaptations of standard internal-combustion engines.

One engine was built by Dr. Roger Schoeppel of Oklahoma State University. Nitrogen oxides are the only undesirable emission, and they are at levels ten times lower than those of a gasoline engine. His approach involves direct injection of gaseous hydrogen into the cylinder, similar to the fuel-injection process in a standard diesel engine. The hydrogen engine is "easy to start, responds rapidly to different rates of fuel injection, and runs cooler under low-to-intermediate loads than its gasoline equivalent."

Dr. Schoeppel is convinced that hydrogen-fueled cars could be on the U.S. market in ten years—and in five if the major automobile makers can't meet the federal automotive pollution standards by the mid-1970s. Charles Gray, now with EPA's Mobile Source Pollution Control Program in Michigan, was project officer of the Health, Education and Welfare department's contract that funded Dr. Schoeppel's work—the only hydrogen-automobile-engine project ever funded by the federal government.

With the current program priorities, there is simply no more funding available at this time within EPA for investigating hydrogen-fueled engines, Gray says, even though they appear to offer "long-term potential," and represent "an area we should be looking at again. The federal government has an obligation to investigate hydrogen as a long-term fuel resource," Gray feels. This is something that shows no signs of becoming an important priority in the automobile industry, at least in the short term.

One privately funded project is a 1971 standard Toyota station wagon converted by a professor-student research team at the University of Miami to operate on compressed gaseous hydrogen. A local Toyota distributor leased the station wagon to the research team for 15 months at a token $1 fee. Within a relatively short time, they had modified the engine to burn gaseous hydrogen—modifications which cost less than $100 to make. There is no difference in performance, they claim. "If anything," noted 23-year-old graduate engineering student Michael Swain, who with Dr. Robert Adt designed the Miami engine, "there's a theoretical four percent gain in horsepower."

Months of road and laboratory tests indicate that at an average cruising speed of 40 mph (2,400 rpm engine speed) the car's engine produced no atmospheric pollutants except nitrogen oxides.

The 1975 federal limits on nitrogen-oxide emissions will be 3.1 grams per mile, the equivalent of 984 parts per million of exhaust. With its 18 ppm, then, the Miami car already produces only a tiny fraction of this strict federal limit. Even the most sophisticated technology for modifying the gasoline-fueled combustion engine will reduce NOx emissions only to an amount seven times that of the Miami engine.

vehicles in America produce more than 90 million tons of air pollutants annually. Rather than

add costly and complicated emission-control devices, says the author, why not change the fuel.

Using yet another variation, the Smogless Automobile Association of Perris, California, has converted two automobiles—a 1930 Ford Model A and a 1960 Ford pickup truck—to hydrogen operation. Last summer Patrick Underwood and Paul Dieges described a fuel system which is based on liquid hydrogen and liquid oxygen storage, with gaseous mixing to the engine.

The fuels are stored in special vacuum "thermos" bottles, or dewars, which keep them supercold at —400 degrees F temperatures. The engine is modified to burn a rich hydrogen-to-oxygen mixture (instead of burning hydrogen with air) and its only exhaust "emission," water vapor, is collected and recycled as engine coolant. Thus, not only is this engine pollution-free, it requires no exhaust system!

A unique concept in the development of the hydrogen-fueled internal-combustion engine is that developed by Marc Newkirk, president of a small Boston firm, International Materials Corporation. Newkirk's system is based on the use of gasoline as a primary fuel, with a slightly modified internal-combustion engine. The gasoline in the vehicle is "reformed" with steam to produce hydrogen, which is the operating fuel of the vehicle. According to Newkirk, until now "everyone has tried to clean up conventional gasoline engines, but nobody has given any attention to treating the fuel before it gets to the engine."

Newkirk's hydrogen-reforming process takes place in a device like a miniature petroleum refinery—a small steel canister fitted into a compartment near the automobile's gasoline tank.

Superheated gasoline (1000 degrees C) reacts with steam in a vaporizing chamber, producing carbon monoxide and hydrogen. A second injection of steam converts the carbon monoxide to carbon dioxide, and the final fuel mixture of hydrogen and carbon dioxide is stored in a small tank for injection into the car's engine. Newkirk estimates that emissions would be only one-tenth of the strict 1975-76 federal limits.

Engine maintenance characteristics after several hundred hours of road and laboratory tests are excellent, says Newkirk, with no spark plug deterioration, no oil fouling or breakdown, and little or no change in the cleanliness of interior-engine parts in contrast to the gasoline engine. Acceleration speeds of the cars have equaled conventional vehicles and during trials they were driven at 60 mph. The reformer could be mass-produced at a cost of $200 to $300, according to Newkirk. Gasoline mileage, however, is reduced to about ten miles per gallon by the addition of the hydrogen-reforming system.

These four approaches are among several examples of hydrogen-fueled engines now running in the United States. Another scheme, tested by Union Carbide Corporation, employs a fuel cell which combines oxygen and hydrogen to produce electricity which drives a

converted Austin. Though in the early stages of engineering, these experimental engines demonstrate the feasibility of using hydrogen for transportation. Three additional problems need to be explored: safety, storage, and production of hydrogen fuel.

The simplest and most common method of hydrogen storage is as a gas under pressure, but this method is bulky and impractical for long-distance (200 miles) range in an automobile. A normal 20-gallon tankful of gasoline weighs about 120 pounds. To store the equivalent amount of energy in the form of hydrogen gas would require an enormous container holding 66 cubic feet of gaseous hydrogen and weighing a ton.

A lighter, more compact means of storing hydrogen is as a supercold liquid. The liquid hydrogen storage tank equivalent to the normal gasoline tankful weighs 353 pounds and stores the hydrogen in a 10.2 cubic-foot tank, four times the size of a normal gas tank.

A team of scientists at the Brookhaven National Laboratory in New York has conceived a promising "storage tank" for hydrogen fuel that they say could easily be adapted to automobile use. They use powdered magnesium metal which can be chemically charged with gaseous hydrogen. Hydrogen is stored in the "tank" as magnesium hydride. Engine-exhaust heat is transferred to the tank to release the pure hydrogen from the metallic hydride. The Brookhaven team has estimated that the magnesium metal storage tank would add about 700 pounds to the weight of a large (3,600-pound) automobile. The car could then be driven for a little more than four hours at 50 mph using hydrogen fuel.

Dr. Lawrence W. Jones of the University of Michigan reported last year in *Science* magazine that the future large-scale uses for liquid hydrogen fuel would logically be in airplanes, long-haul trucks and city buses. He recommended the development of replaceable tanks (dewars) which could be quickly installed on vehicles. For private cars, he suggested "local hydrogen refrigerators" or a "home delivery" of liquid hydrogen by service stations.

Dating back to the tragic experience of the *Hindenburg* explosion, considerable public fear exists over the explosive potential of hydrogen. However, wrote Dr. Jones, "In many ways hydrogen is safer than gasoline in that any escaping hydrogen goes directly into the air rather than remaining as a slowly evaporating liquid." He cited a potentially serious accident in which a truck carrying liquid hydrogen went off a mountain road and broke apart, spilling the tanks' contents: "No fire ensued and the driver walked away."

EPA's Charles Gray says that it is conceivable that hydrogen fuel tanks could be designed "so that on impact the fuel tank would rupture and the hydrogen would quickly disperse. Even if the hydrogen ignited, it would probably be rising so rapidly that you wouldn't get an explosion. Such tanks are not commercially available, though a similar—and safe—storage technology already exists for natural gas.

In addition to its vast potential for transportation, hydrogen could supplant all the uses of natural gas for fuel in the United States, including heating and air conditioning for buildings and fueling gas turbines for the production of electricity. Before such a "hydrogen economy" can emerge, a major concern must be: Where is the hydrogen going to come from and how much is it going to cost? Hydrogen is already being produced for many industrial applications, most of it by reforming hydrocarbon "feed" materials, such as natural gas, propane and butane.

How to produce hydrogen

Another commercially viable process, electrolysis, uses electricity to break water down to produce hydrogen and oxygen. Any source of electricity can be used.

Scientists at the Institute of Gas Technology (IGT) recently estimated that with further improvements in electrolyzer technology, hydrogen may become available at prices competitive with expensive imported natural gas. The IGT hopes that a proposed new generation of nuclear power reactors, called "breeder reactors," will be available in a few years to provide almost unlimited supplies of electricity to fuel the water electrolyzers. Many hydrogen-fuel researchers are pinning their hopes on yet another experimental power device, the nuclear fusion reactor. Nuclear fusion works on the principle of the sun's own heat source, as well as that of the hydrogen bomb.

A radical innovation for the fusion process, suggested by Dr. William C. Gough and Dr. Bernard Eastlund of the Atomic Energy Commission's Division of

Controlled Thermonuclear Research, is that instead of producing electricity from the fusion reactor, photons could be produced. Photons, the energy particles of the sun's rays, would be generated from the fusion reactor's core and channeled to a "water vapor cell," where this synthetic solar energy would directly convert water to its constituent parts—hydrogen and oxygen. This process, called photolysis, occurs in nature as photons of sunlight break down water vapor to hydrogen and oxygen in the Earth's atmosphere. Dr. Eastlund noted that "the fusion reactor is really imitating the sun, and we're suggesting you go back and do the same thing the sun did."

Conjuring the gods of sun and sea

Another long-range possibility for production of hydrogen fuel is the use of solar radiation falling on the Earth's surface to power machines which would break hydrogen out of water. One ambitious scheme, called "Helios-Poseidon," after the gods of sun and sea, was suggested last April by a Michigan engineer, William J. D. Escher. It would use vast arrays of solar energy collectors (mirrorlike energy-concentrating devices) to heat steam-turbogenerators, which in turn would produce electricity for the conversion of sea water, purified first by simple solar distillation, to hydrogen (and oxygen) through electrolysis. The hydrogen production plant could be in the mid-Pacific Ocean near the Marquesas Islands where there is little annual cloud cover, allowing bright sunshine year-round.

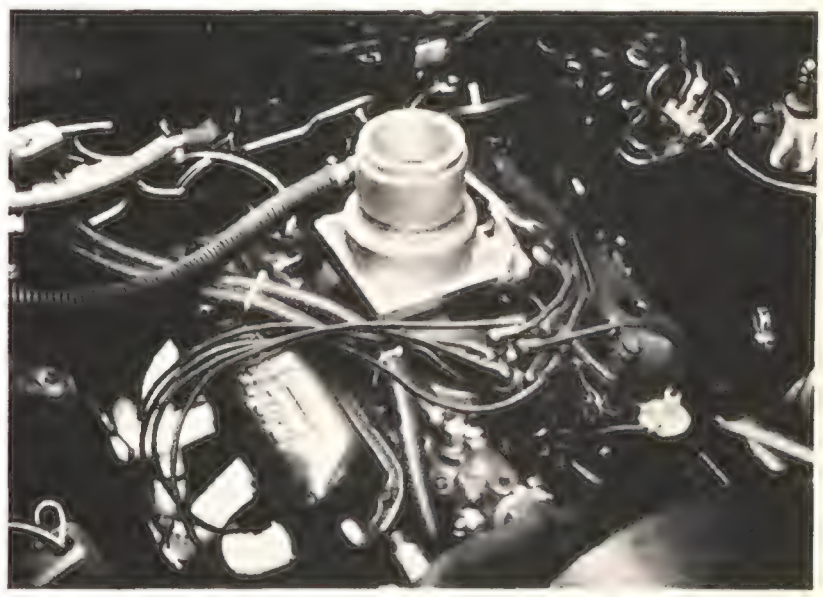
Hydrogen fuel, as well as oxygen produced from the solar electrolysis system, would be liquefied to supercold (cryogenic) form and transported to home port in special tankers. The "Helios-Poseidon" plant would occupy a square area of ocean about 4.3 miles on a side (see next page). Its basic advantage, Escher notes, is its low environmental impact. No natural resources or fresh water would be depleted for initial fuel and no land would be used up.

Other schemes for hydrogen production include windmills and the use of enzyme-enriched green plants in large ponds. Techniques already exist for the large-scale conversion of organic and agricultural wastes into methane (natural gas) which can be further converted to hydrogen. Another immediate source is coal, the most abundant of all fossil fuels in North America. In a rush to supplant the diminishing supply of natural gas with a synthetic substitute, a number of coal, oil and gas companies have begun developmental efforts to produce natural gas (methane) from coal. The Nixon administration places a high priority on the technology of gasifying coal, and the Interior Department is spending $75 million on coal gasification.

Dr. Derek Gregory of IGT believes that coal gasifi-

Florida's Robert Adt (left) and Michael Swain altered this Toyota to hydrogen operation for under $100.

This Model A Ford burns hydrogen and oxygen, recycles its "exhaust" (water vapor) to cool the engine.



With minor changes to the carburetor (center), this Boston car uses clean, hydrogen-reformed gasoline.

cation plants will eventually produce *both* methane and hydrogen, depending on user needs. He notes that the transmission of hydrogen in pipelines and its use as a fuel are not unknown in this country. "Twenty or 30 years ago, when we manufactured gas from coal, the gas in everyone's kitchen was 50 percent hydrogen." Today, he says, the transition to higher hydrogen concentrations would not be difficult.

Nuclear scientists at the Ispra (Italy) Euratom research center have developed a chemical process which uses the heat produced by a nuclear reactor to decompose water to produce hydrogen fuel. Dr. Cesare Marchetti, director of the Materials Division of Euratom, says that the chemical decomposition method was being pursued by his group because the process is half as expensive and twice as efficient as splitting water in an electrolyzer. Furthermore, hydrogen can be both transmitted and stored more readily than electricity. Existing natural gas pipelines could be adapted in many cases for hydrogen transport.

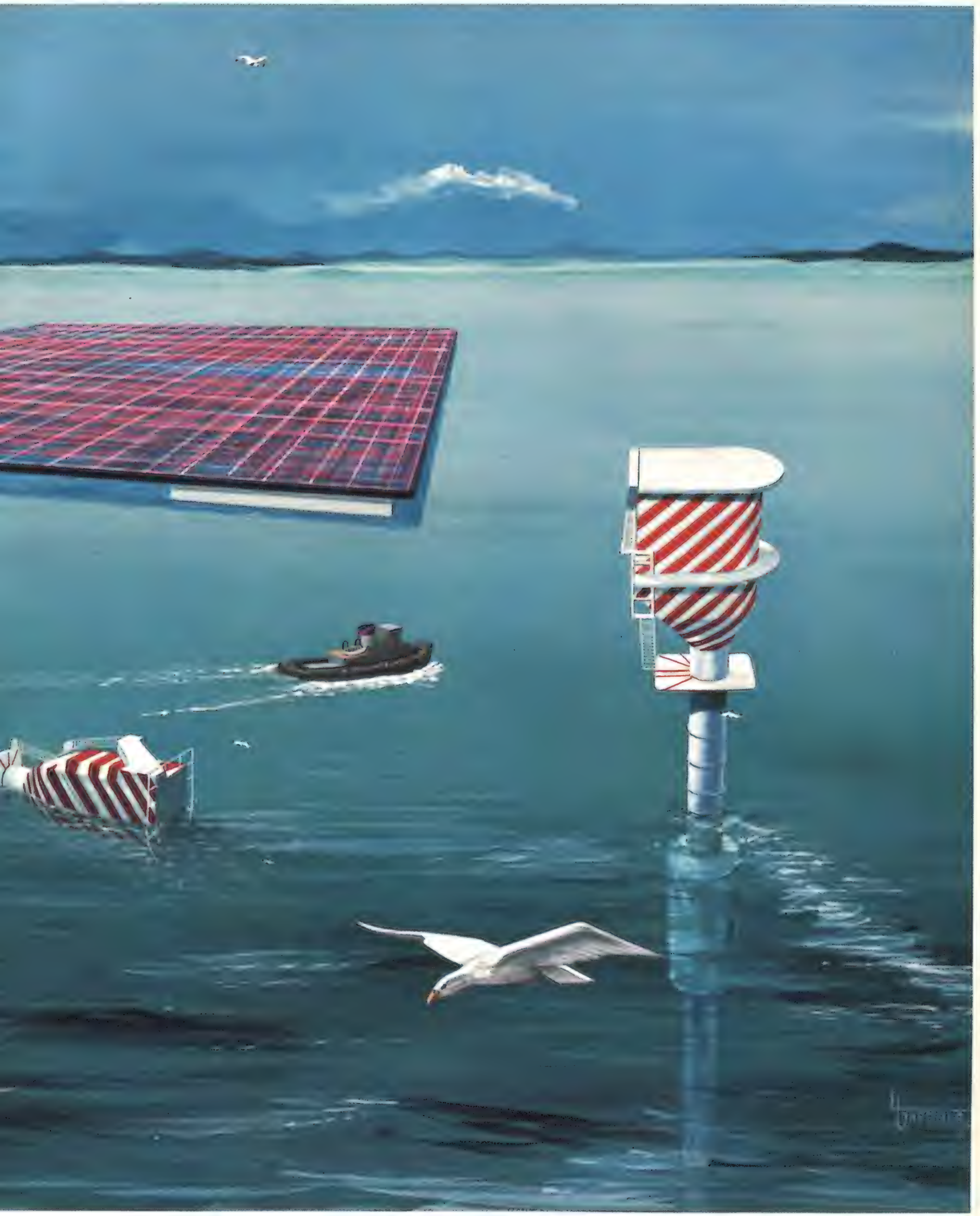
Clean, efficient and unfunded

In a projected "hydrogen economy," no unsightly power lines would slash continents with enormous rights-of-way and the environmentally destructive method of storing peak-period electrical energy as water in mountain reservoirs would be eliminated. Hydrogen can be stored (similarly to the storage of natural gas) simply by pumping the gas into underground caverns, certain types of sandstone formations and depleted oil wells. When needed during peak-use periods, it can be pumped out of the ground and into a pipeline. When it reaches the final engine, house heater or electrical generator, it can generate energy at that point efficiently, cleanly and quickly.

The U.S. government is apparently spending nothing for specific research on hydrogen-fueled vehicles or other aspects of an integrated, modern, clean hydrogen-energy system. The only industry that is actively supporting the concept of the hydrogen economy is the now-threatened natural gas industry.

In a recent article in a European scientific review, Dr. Marchetti described many of the aspects of a hydrogen economy, but mused that "politics is a far more complicated sphere than technology. . . ."

To provision a hydrogen-fueled future, an engineer has suggested a vast array of solar collectors to get energy for producing hydrogen from sea water. In foreground, artist has shown the kind of buoy (one floating and one erect) upon which solar array, seen completed in background, would be built.



By Gerald Carson

Fantastic animals prowl tall timber of our mythology

From the long-clawed, green-scaled gowrow to the weeping squonk that melts in its tears, here's America's wild and woolly taxonomy

The extent of the animal kingdom is almost beyond imagining. The total fauna amounts to some thousands of creatures which Man has loved, hated, feared, worshiped, eaten, exploited and often exterminated. All the while, in addition, fable and legend have given us an apocryphal biology based on hearsay or faulty observation. We have the unicorn, the basilisk, the winged bulls of Assyria, the frightening griffin of the Hittites, the chimera, the phoenix, sphinx, sirens and sea horses. This amounts to a vast archive of European and Oriental mythical animals.

What is less widely known is the distinctly American contribution to this menagerie that never was. Historically, Americans have always had a taste for droll stories and odd bits of misinformation, imparted with artistry and a straight face. So exuberant wonder tales have grown around queer critters that crawled, leaped, marched, prowled, bounded, swam, flew or burrowed.

The information presented here has been gathered with diligence and loving care, and it is believed to be either reliable or unreliable or somewhat doubtful. Following this caveat, I quote from sources, named and nameless, who have enriched North American animal mythology.

Early hunters, explorers, land agents and settlers told entrancing tales of the snake that takes its tail in

Author of many books, Gerald Carson will have his most recent, Men, Beasts and Gods, *published by Scribner's this fall.*

Our mythical menagerie was born of the tall stories of hunters, farmers, loggers, salesmen and housewives.

Strange beasts were inspired by our vast and varied landscape which this composite creature stalks.

Illustrations by Brenda M. Tilley

its mouth and rolls toward its victim (to outrun it, climb over a fence—it has to unhoop to get through). New Englanders wrote letters to their rats, telling them to depart, where to go and how to get there. Greased, rolled up and tossed into ratholes, the letters were "duly read, marked and inwardly digested."

From backwoods settlements have come descriptions of the sidehill gouger, the squonk, the hodag, the cactus cat, the gumberoo, the wampus cat and the augerino. This last is an enormous corkscrew-shaped worm that drills underground. It exists for the sole purpose of letting water out of irrigation ditches.

Some stories deal with the surprising things familiar animals do (squirrels that migrate across rivers by launching shingles and hoisting tails for sails) or strange powers they possess (unproductive men in North Carolina who ate the teeth of the alligator's right jaw to restore potency). The beaver's tail, the hare's eggs, the cod's head were devoured for the same purpose. Other yarns come straight from the lips of venerated Americans. Benjamin Franklin described, for English consumption, American sheep with tails "so laden with wool, that each has a little car or wagon on four little wheels, to support and keep it from trailing on the ground." He also insisted that whales were so fond of codfish that they pursued them *up* Niagara Falls, making a grand leap "esteemed by all who have seen it, as one of the finest spectacles in nature."

Sheep with tails so laden with wool that each has a little wagon to keep it from trailing on the ground.

A more surprising bit of nature-faking comes from the pen of Cotton Mather. A bulwark of Boston Puritanism, Mather was no gay deceiver. But he had a taste for marvels, especially if they bordered on the macabre. So we find the divine, who was enormously proud of being a member of the Royal Society of London, passing on the news in the Society's *Philosophical Transactions* that if a rattlesnake bites the edge of an ax, the poison discolors the metal, and the affected section will chip away when used.

New Englanders wrote letters to their rats, telling them to depart, where to go and how to get there.

Another clergyman, Samuel Peters, wrote spitefully about his town of Windham, Connecticut, after he was roughly handled by Liberty Boys for his Tory sympathies during the Revolution. He claimed that a frog army, led by bullfrogs and followed by peepers, hopped through Windham one night looking for the Winnomantic River, and the townsfolk thought the French and Indians were attacking. They ran for their lives, then sneaked back to find someone they could surrender to.

Even John James Audubon played games with fanciful species. He was visited in 1818 by Constantine Samuel Rafinesque, an eccentric French naturalist, who was delighted by the plants and animals of the American Middle West and developed a passion for announcing new species. Rafinesque was also gullible. Audubon may have wearied of those announcements of new varieties of fish. In any case he could not resist supplying Rafinesque with sketches of ten nonexistent species of fish. Rafinesque rushed into print with descriptions—and so disrupted for years the science of ichthyology. In his *Ichthyologia Ohiensis or Natural History of the Fishes Inhabiting the River Ohio,* Rafinesque hailed one of Audubon's creations, the Devil-Jack Diamond-Fish *(Litholepis adamantinus),* as the "wonder of the Ohio." Naturally. It supposedly grew to a length of from four to ten feet, was known to weigh as much as 400 pounds and was cov-

ered with diamond-shaped scales so hard that a bullet could not penetrate them. Rafinesque, poor fellow, said that he had been shown some of its "singular scales" and had personally seen a Devil-Jack Diamond-Fish, "but only at a distance."

In the journal of his first voyage, Columbus recorded a Haitian Indian tale that the New World contained men born with one eye in the middle of their foreheads. A later explorer, Père Marquette, saw two hideous dragons or birds, carved and painted, high on a Mississippi River bluff between the mouth of the Illinois River and the site of present-day Alton. I grew up nearby and understood the enchantment and sense of menace in the stories of these petroglyphs and pictographs. "They are as large as a calf," wrote Marquette, "with head and horns like a goat; their eyes red; beard like a tiger's; a face like a man's. Their tails are so long that they pass over their heads and between their forelegs, under their belly, and ending like a fish's tail. They are painted red, green, and black. They are so well drawn that I cannot believe they were drawn by the Indians."

Later, Father Louis Hennepin, another friar-explorer, also described the pictures. They were known, together, as the "Piasa bird" ("man-devouring"). Passing Indians offered tobacco to appease the Evil Spirit, for they said the monsters once lived in this bluff country and carried away humans to be torn apart and eaten. One wonders whether the Piasa bird could represent a dim racial memory of the earliest form of bird.

Toward the middle of the last century, the Piasa bird was painted over with patent-medicine advertisements. Some of the rock face was blasted away to provide building stone for a state prison.

Modern breeding techniques have contributed some useful animals. The U.S. Signal Corps has been saluted for crossing a homing pigeon with a woodpecker. The result is a bird that not only delivers the message but knocks on the door. A species of Arkansas bees produces twice as much honey as the ordinary bee. Having been successfully crossed with a lightning bug, they can still gather honey into the night.

Paul Bunyan, legendary hero of the logging camps, imported some bumblebees to combat the giant mosquitoes of the Chippewa River region. The two species fought for a while. Then the woods became almost unbearable because the hymenopterous and dipterous insects interbred and produced progeny with stingers at *both* ends.

A traveling salesman, William Miller, is credited with bagging a huge reptile near Marshall, Arkansas, in 1897. He gave it the name gowrow. No one saw the beast locally because Miller said he shipped the skin and skeleton to the Smithsonian. But museum officials have disclaimed any knowledge of the gowrow. It was reportedly thick-skinned, 20 feet long and enormously tusked, with short legs, webbed feet, a vicious claw on each toe, a body covered by green scales and a back bristling with stubby horns. Pete Woolsey, who used to run a restaurant in Bentonville, Arkansas, was offended when a visitor was skeptical about the gowrow.

"I don't see nothin' so unreasonable about it," he said. "Them scientists over at the State University are tellin' people that there used to be elephants right here in Arkansas. *Elephants,* mind you, with red wool on 'em two-foot long! Would you rather believe them professors, talkin' about red elephants in Arkansas before America was *discovered* even, than my Grandpaw's story of what happened in his own lifetime?"

The sidehill gouger *(Membriinequales declivitatis)* flourishes in hilly country. Through evolution it has developed two long legs on the downhill side and two short ones (by a good 4 inches) on the uphill. Thus equipped, the animals always run around their hills in one direction—some going clockwise, some counterclockwise. Not being able to dodge each other, a terrible fight ensues when the two varieties meet. The gouger or hoofer, as it is also called, has been likened to a cross between a buffalo and a mountain goat.

The gouger is dangerous, but easy to avoid. If you are chased by one, take a couple of steps up- or downhill. The gouger cannot turn without falling and breaking its neck. There is a certain hollow in Marion

Crossing a bee with a lightning bug produces offspring that can gather honey after dark.

The goofus bird builds its nest upside down and flies backward in order to see where it has been.

County, Arkansas, reportedly half full of gouger bones.

Much speculation surrounds the squonk *(Lacrimacorpus dissolvens)*. Jorge Luis Borges, professor of English and American literature, University of Buenos Aires, and onetime visiting professor at the University of Texas and Harvard, says that the squonk's range is limited to the hemlock forests of Pennsylvania. Since it weeps constantly, hunters follow it by its tear-stained trail. The tears dissolve it. Another authority notes: "Mr. J.P. Wentling, formerly of Pennsylvania, but now at St. Anthony Park, Minnesota, had a disappointing experience with a squonk near Mont Alto. He made a clever capture by mimicking the squonk and inducing it to hop into a sack, in which he was carrying it home, when suddenly the burden lightened and the weeping ceased." When the hunter investigated, he found "nothing but tears and bubbles."

From Idaho comes the wampus cat with a right arm which works on an extension system like a folding pruning hook. The wampus cat is incredibly fast in thrusting this arm out to catch its prey. It is especially fond of eagles—which may explain why conservationists are anxious about Idaho's eagle population.

Another member of the cat family once ranged the dry Southwest. This cactus cat *(Felis spinobibulosus)* lived on cactus and was especially plentiful between Prescott and Tucson, Arizona, but is now practically extinct. It was well described in 1910 by William T. Cox, an expert on nonacademic zoology: "The cactus cat has thorny hair, the thorns being especially long and rigid on its ears. Its tail is branched, and upon its forearms above its front feet are sharp, knifelike blades of bone. With these blades it slashes the base of giant cactus trees, causing the sap to exude. This is done systematically, many trees being slashed in the course of several nights as the cat makes a big circuit. By the time it is back to the place of beginning the sap of the first cactus has fermented into a kind of mescal, sweet and very intoxicating. This is greedily lapped up by the thirsty beast, which soon becomes fiddling drunk, and goes waltzing off in the moonlight, rasping its bony forearms. . . . and screaming with delight."

Another denizen of the Rockies is the photophobic Ratchet Owl. This curious bird always faces away from the sun—westward at dawn, eastward at sunset. Its neck is equipped with a ratchet that permits a clockwise adjustment as the Earth moves around the sun. At night the bird releases the ratchet so it can return its head to the west-facing position. The unwinding ratchet can be heard afar.

Lumberjacks have made many contributions to ornithological lore. They reported the gillygaloo, or hillside plover, which lays square eggs that cannot roll from the nest. Hard-boiled, they serve in the lumber camps as dice. Another inhabitant of the deep forest is the goofus bird. It builds its nest upside down as does the fillyloo crane. The latter's eggs are lighter than air; if pushed out of the nest, they ascend. The goofus bird or flu-fly bird also flies backward instead of forward. Old-timers say it doesn't care where it is going, it only wants to see where it has been. It has a marine relative, the goofang. This odd fish swims backward to keep the water out of its eyes.

Among the shyest of woodland creatures is the hodag, like the squonk given to weeping. The reason is that it is ugly and knows it, being buck-toothed, short-legged, spiny-backed and spear-tailed. The animal has *some* admirers, at least in Wisconsin, where the "World's Largest Snowmobile Marathon," held annually at Rhinelander, is known as the Hodag 50.

I wish I could bring you encouraging news about the hinge-tailed bingbuffer and the chipmunks which feasted on prune stones discarded from Bunyan's cook shanty and grew so large and fierce they could tackle a bobcat; also the upland trout which nested in trees. But the bingbuffer has been declared extinct: The last one was killed in Osage County, Missouri, about 1881—maybe the spring of 1882. The others are on the endangered species list of mythical animals, victims of our times. It is the familiar story of shrinking habitats, real-estate developments, four-lane highways, shopping centers, snowmobiles and outdated thinking in state and federal conservation departments. No sightings have been reported for years and years.

Buck-toothed, short-legged, spiny-backed hodag weeps copiously because it is so ugly.

By Stuart Struever and Pension Thurmer

American culture, 12 layers deep, dug up in Illinois

Young diggers team with laboratory experts to reveal the horizons of Man's past and a novel method of practicing archaeology

Not far north of St. Louis, prehistoric man, 4,500 years ago, was on the verge of discovering the utility of a portable cooking utensil made of baked clay. Yet another 2,000 years passed before what we know as pottery was used in this valley of the lower Illinois River. We are learning these and other facts about prehistoric man and gaining fresh insights because of some new concepts in archaeology. These are being applied with a force of 120 professors, college and high school students at a site called Koster and in laboratories in the town of Kampsville, Illinois. Koster, named for the farmer who owns the property, is the kind of site archaeologists dream about but seldom find in North America. Kampsville, a small riverside community that was once a thriving steamboat stop, is the scene of a long-term experimental program aimed at developing new methods for analyzing the excavated remains of early man.

Why go to such pains to salvage evidences of prehistoric life? In answer, think of Man's history as the interaction of three "systems": his body, his cultural practices and his environment. Like other animals, Man has had to adapt to various environments. But he has been increasingly successful at it because his cultural system greatly expands his body's ability to cope.

Archaeologists are beginning to determine how en-

Dr. Struever teaches archaeology at Northwestern. Pension Thurmer is the pen name of an amateur participant in the Illinois River valley project.

Student excavators, 12 to 14 feet deep in Koster's main trench, reach horizon 6, compacted remains of an Indian community dating back to 2500 B.C.

vironmental changes have affected Man's body and culture, or how new cultural influences affected his body and his environment. Our program at Koster and Kampsville is an experiment in achieving these intermediate goals, perfecting techniques that other archaeologists can apply.

Our explorations in the lower Illinois River valley began in 1959, centering on the Hopewell, or Middle Woodland culture, which flourished from about 100 B.C. to A.D. 450. Like other rivers in the Midwest, this one is a system of small valleys—from the air they look like narrow converging pencil lines—which in prehistoric times supported vast populations of edible plants and animals—a harvestable resource for Man.

In 1968, we expanded our program to include the Late Woodland culture that followed Hopewell. This enlarged our study by about 1,000 years and drew us to Koster. Harlin Helton, a farmer living near the Koster place, had been collecting artifacts for about 40 years. A version of the *End of the Trail* (see below), on display in Pete's Tavern at Spanky Hollow, is insured for $10,000 because it is made entirely of projectile points that Helton collected. For two years he badgered us to take a look at the Koster farm.

Moreover, Gregory Perino of the Gilcrease Institute in Tulsa had dug a Late Woodland cemetery on the Koster farm and put down a few test pits in the north field. Perino, who undoubtedly has excavated more Indian burials than anyone else in this country, was impressed with the way occupation levels—"horizons"—were separated by "sterile" soil. He suggested that there might be some Archaic (pre-pottery) cultures represented at Koster.

It is easy to see how people could have lived on this site. Picture a small, recessed valley above the floodplain of the lower Illinois River, sheltered on three sides by bluffs and high ground against prevailing westerlies and winter northerlies. It is watered by a natural spring. It is filled in, to a depth of many feet, with soil composed of fine, windblown dust—loess. This is the "sterile" soil that Perino dug through. The cultural levels—"middens"—with artifacts showed up as dark brown, stained levels.

With Perino's ideas and Helton's finds, we spent three weeks in exploratory excavation in 1969. We dug nine six-by-six-foot test pits in the north field, within about one acre. We made out six occupation levels, all within this relatively small area. Four of them, apparently, were pre-pottery, or Archaic.

Though our deepest pit was almost 11 feet, we did not penetrate the sixth occupational level, or horizon. However, we learned enough to change our plans. We now emphasized the study of the many Archaic horizons underlying those of the post-Hopewell cultures.

In 1970 we returned for a full field season (June to September) with a crew of high school and college excavators and some volunteers. We spotted 50 test pits over about three acres. Yet further digging in the original lot confirmed that we were on target there.

As an aid in detecting new horizons, we used a probe, a five-foot rod of spring steel with a stainless steel ball at the end. When spiked into the ground this tool has a characteristic feel and sound if it strikes burnt limestone (an indication of human activity) or flint (a projectile point, or perhaps a waste flake). If it penetrates organic material, a small amount of the darker soil clings to the top of the steel ball. All these signs told us: "Keep going!"

End of the Trail—all in projectile points—adorns Pete's Tavern at Spanky Hollow.

Two 7,000-year-old burials

At 25 feet we learned that ancient man had come to this spot ten times. At 28 feet we found the well-preserved and fully articulated skeleton of a domestic dog—an 11th occupation. Two small hearths of charcoal in front of its feet suggested a ceremonial burial. The burned wood gave radiocarbon dates ranging between 5000 and 5100 B.C.

Last summer we found the skeleton of an 18-month-old infant, also in horizon 11. Its body had been covered by powdered red hematite, and our find marks one of the earliest known instances of this burial practice in North America. Between the dog and the baby

Dark strata in this earth wall are layers showing evidences of occupation by man.

Aerial view of Koster excavation shows the main L-shaped trench surrounded by test pits.

is the area where we sought to learn all we could about the daily lives of these ancients.

Ira Fogel, geographer and soil scientist, had been urging us to use a core drill to find more sites like Koster. Late in the summer of 1970, we tested his device at Koster with a four-inch drill from the University of Illinois. At 34 feet we came up with evidence of an even older occupation—horizon 12. This year we are excavating our trench—a deep, L-shaped cut, 84 feet long and 42 feet wide at one end and 30 feet wide at the other. It contained 76 six-foot squares, each of which is dug in three-inch levels. At the end of last summer we were at 18 feet—horizon 8. In this trench our student excavators toil. Every shovelful goes through screens of half-inch mesh to extract artifacts, bones, shell and burnt limestone.

Let's consider that of at least 10,000 Archaic sites in the United States there has seldom been one that contained at least 12 horizons, and never one with such an ideal interbedding of cultural and sterile layers, so that each community ruin is overlaid by protective soil. Also, never before has the soil been more favorable for preserving bone, shell, fish scales and even plant remains over the *entire* occupational span. Even tiny charred seeds have been recovered and identified.

Thus we have here a fossilized layer cake of Archaic life. Koster expanded our acquaintance with Stone-Age life in the lower Illinois River valley to at least 7,200 years. It also gave us a rare chance to apply laboratory methods on a scale never before attempted. We could excavate occupations to the Archaic base life dating from 6000 B.C. There are 12 common intermittent horizons at the Koster site dating from 6000 B.C. to A.D. 1200.

What diseases struck ancient man? How nutritious was his diet? How did he exploit his incredibly rich resources? How did his tools change, and why? What kind of art did he produce and what effect did it have? How did his environment change, and how did his culture change to cope with new challenges? To answer such questions, archaeologists turn to other fields —geology, palynology (study of pollen), malacology (study of mollusks), zoology, botany, physical anthropology, chemistry, mathematics, nutrition, trace-element analysis and computer technology. In Kampsville, laboratories operate full time while excavation is still under way at Koster, nine miles away. Thousands of excavated stone artifacts, animal bones, nuts, shells, seeds and other cultural remains are washed, catalogued and analyzed within a week of the time they come out of the ground, in almost production-line fashion. This way we can discover gaps in the data we are getting, and so shift our excavation strategy.

In Kampsville, where a dollar of research money buys what would cost at least four dollars in many other places, a botanist now works in the town drugstore, long since out of business. The zoology lab is housed in a former church, originally built of logs. Archaeology and malacology labs are in recently vacated homes. Headquarters is a two-story brick building that, for 55 years, housed a hardware store.

Karl Butzer, professor of geology and archaeology at the University of Chicago, studies the composition of the soil and learns what rainfall and temperature conditions were like during the occupations. He tries to tell the span of the sterile layers, the "missing links" when people were living elsewhere. James Schoenwetter of Arizona State University, a palynologist, studies pollen in soil taken from each three-inch level. Sometimes the sample of seeds and pollen is too small for a balanced reconstruction of prehistoric plant communities. Then Dr. Irwin Rovner of the University of Wisconsin will study "opal phytoliths," tiny mineralized structures—their shape and form identify the

plants from which they came. Plant opal phytoliths also contain minute amounts of carbon, which could be used to date deposits.

Changes in climate and habitat could be important in our descriptions of life over that 7,200-year or more span. "Nancy says there were no notable changes in the environment over the period people lived at Koster," says Manfred Jaehnig, professor in anthropology at Sangamon State University, Springfield, Illinois, and head of the malacology lab. "I think she's wrong."

"Nancy" is Nancy Asch, graduate student in botany at the University of Michigan and head of the botany laboratory. She and Jaehnig get their evidence from different sources. Nancy uses the technique called "flotation." When soil is screened in the field, a coarse mesh lets anything under a half-inch fall through. The excavator takes a bushel basket-sized sample of this screened soil from each excavation unit and washes it in a tub fitted on the bottom with a window screen-sized mesh. Soil particles drift out as the tub is swirled, leaving a residue of tiny bones, fish scales and charcoal, hardly detectable to the naked eye until separated from the soil. Later, in a bath of water and zinc chloride, the charcoal floats to the top, bones, scales and other residue sink, and the separation is complete.

"You need only a small part of the growth ring to tell what species of tree or plant—or at least genus—it came from," Nancy says, studying a charred piece of wood. How does she know what a carbonized piece of oak, for example, looks like under the microscope? She has collected specimens and carbonized them. This partial burning does not change the structure. Similarly, she determines that a big part of the diet of the Koster people—all through the Archaic period—consisted of hickory nuts, a good source of fats and proteins. She finds charred remains of many other kinds of trees and plants that grow in the region now: hazelnut, pecan, walnut, oak. Hence her conclusion: "There were no drastic changes in the climate from horizon 11 times to post-Hopewell (A.D. 800-1200)."

Manfred Jaehnig's evidence comes from land snails, some of them so small that 40 would fit on the tip of a finger. At the site, he trowels out two-to-three-liter soil samples from each three-inch level in the walls of the deep pits, then screens the soil through a fine mesh. Based on the habitats of the various snails recovered—which are sensitive indicators of past environments because they don't move about easily—he reconstructs the site as being forest-covered most of the time and attractive to moisture-loving snails during horizons 6, 8 and 11 occupations. In between, and from the horizon 6 period until the present, he maintains that the site was a grassland, and the climate was warm and dry.

"When Fred finds snails in the horizons, but not in the sterile layers," says Nancy, "it merely means they were attracted there by human refuse."

"Not so," says Jaehnig.

This stimulating interaction of minds typifies life on the Koster expedition. Each helps the other think because they work and eat together for an entire summer. Set up like an isolated academic commune, the learning level is high.

Some material from the flotation process—fish and animal bones and fish scales—go to Fred Hill for study, along with all other faunal material. He is an aquatic biologist at the University of Louisville and heads the Koster zoology lab.

To determine the seasons when people occupied Koster, Hill makes hydraulic-heat impressions of fish scales on plastic slides. Under magnification, the growth rings can be seen. Since a new ring is formed each year, the time of year the fish was caught can be estimated by measuring it to the complete distance between earlier annual rings.

Other clues to seasonal occupation are provided by the absence or presence of migratory waterfowl remains, the state of antler growth, the ages of fawns that were killed (fawns are born in early summer). The rate of growth of freshwater mussels and drumfish also indicate changing environmental conditions.

Missing bear and elk

Notably absent from recovered animal remains are black bear and elk, both known to have been present in the valley. "In some cultures in the region," says Hill, "only the teeth and jawbones of the bear are found, usually with burials of high-status persons. Other parts of the skeleton probably were ceremonially disposed of. As for elk, they might have been hard to hunt down. That would make them an inefficient resource, when other animals were so available."

We've installed a computer terminal in Kampsville and connected it to a computer at Northwestern University in Evanston, to build an information bank for sophisticated decision-making. Since our "layer cake" is not evenly structured (there are undulations in the horizons, with dips and ravines), the computer will store such data as density of limestone per three-inch level in the various squares that are dug, the amount of igneous rock, the quantity of flint, the weight of mussel shell, the number of animal bones. All of these help define the depth and character of each community ruin.

Analysis of excavated material by computer will give us a picture of what existed in the various horizons: a living floor, a roasting area, a mussel-cracking location, a tool-manufacturing place, a garbage dump. The computer will also tell us where the excavators are making errors so that they can be corrected.

New information will be added to the computer bank as digging goes on; information from previous seasons has already been stored. By drawing on it, the computer will print out graphs—we call them "histograms"—showing what food sources were being exploited at various times. The computer also helps to classify projectile points since it can describe standard forms by their shared characteristics.

Where a computer cannot help

The computer is of little help in one respect, however—determining the function of many artifacts. Tom Cook, Ph.D. candidate in anthropology at the University of Chicago, heads the artifact laboratory. Here, wear patterns, seen under the microscope, often provide clues to use. Something which looks like a spearpoint may show striations along one edge only. That means it was probably used as a knife.

In questionable cases, however, one hypothesizes that a particular artifact could have had a certain function. You test this, then, by manufacturing the artifact and using it in the hypothesized way. If your version of the artifact shows similar wear and breakage patterns as those of the prehistoric tool, your theory holds.

One new artifact type found at Koster is the channel-basin metate. This 20-to-50- pound implement, used in cracking or grinding nuts and seeds, has an oval basin about eight inches long and three-fourths of an inch deep. Was this formed by use?

An assistant in the artifact lab, Rose Duffield, goes out in the area around Kampsville and finds a suitable igneous rock. She pecks and grinds it with a chert hammer, spending about three hours pounding out the shape and another two hours smoothing the simulated artifact with sandstone. She concludes that the metate probably was formed at one time and that the basin

Malacologist Manfred Jaehnig checks core samples for snails that reveal ancient climate changes.

Adult skeleton from horizon 6 shows flanging of lower vertebrae, indicating he had back trouble.

Skull, 1,000 years old, is uncovered at another site hastily excavated before a road was put through.

was not worn in by use. She surmises further that the function of the basin probably was to catch the processed nuts or seeds as they were ground or pounded.

"Plummets" have confused archaeologists for a long time. These teardrop-shaped objects, which look something like plumb bobs, are thought to have been used as bolas, to be thrown at the legs of running animals to bring them down. Another staff member, Lynne Goldstein, made a study of the collections of local residents and determined that plummets were found most often on shorelines or in the dried-up beds of lakes. This distribution strengthens another interpretation—that they were used as weights for fowling nets.

Some artifacts are also subjected to trace-element analysis. A gamma-ray spectrometer determines where the raw material was obtained. Combined with similar information from other sites, conclusions can be reached as to group territories, seasonal migrations and trade practices. The red ochre, or powdered hematite, found even in the earliest occupation could not have been obtained any nearer than in Missouri.

Preliminary analysis at Koster shows advancing adaptation in the people who lived there over the thousands of years of habitation. But it took an incredibly long time for new methods and resources to be adopted. Archaeologist David Asch points out that new food-getting strategies seem to have appeared along with population increases. Yet the population increased slowly, often staying far below the capacity of the area, Asch believes "something other than food supply was controlling human population."

Change at a snail's pace

Archaic man at Koster had plenty of leisure time. Yet there is no evidence to support the theory that when man is freed from his preoccupation of getting food he elaborates his culture. The slowness of culture to advance is illustrated by our opening statement that man at Koster was on the verge of discovering pottery, but that it took another 2,000 years for it to come into use. The "pot" found was a beautifully formed, round, baked-clay hearth-liner in horizon 6 (c. 2500 B.C.). Unlike pottery, it was not portable.

For some 3,000 years, between horizons 11 and 6, diet was primarily shellfish, hickory nuts and deer. Then people added fish, waterfowl, wild turkey, raccoon and rabbit. There was an increase in harvesting mussels from backwater lakes. Tens of thousands of tiny bones from five-inch fish tell us that men seined these from drying-up lakes after river floodwaters receded. Man's tool kit also expanded to include grooved axes, bone awls, limestone net weights. His trade contacts increased: We found galena ornaments and copper beads, neither mineral being local. Of nine burials,

Museum in former meat market displays Koster finds like encased infant burial beside Dr. Struever.

most were skeletons of people from 10 to 20—healthy years. What this denotes we cannot say.

Perhaps less than a generation remains to salvage the evidence of prehistoric life in the lower Illinois valley, where we know man was living 10,000 to 12,000 years ago, possibly even earlier. However, we face the problems of modern civilization. When a highway was built through Kampsville, quantities of artifacts were bulldozed out of the roadbed. Now two planned bridges would sweep the entire valley into the St. Louis metropolitan area.

Another problem is money. Our 1970 goals were reached on a budget of $35,000. Last year we needed more than twice that amount, and our season would have been cut short if the people of Kampsville hadn't rallied to our aid with a fish supper. They raised about $700 from dinners and another $300 from bingo.

The Foundation for Illinois Archeology, a nonprofit, tax-exempt corporation, serves as a clearinghouse for contributions. Practically all archaeology today is performed by universities and museums. The Foundation indicates the need for an archaeological institute on a large scale, the purpose of which is to assemble funds, facilities and expertise for such researches as our experiment at Koster.

Our research into human-cultural-environmental interrelationships at Koster has proved fruitful. It gives archaeologists an illuminating contrast to the findings of the Near East. Yet we have only scratched the surface. Here, as in all of archaeology, new findings await us which can open our minds to Man's development.

Three-inch rain produces a mud bath in the main trench for Ann Palkovich of the University of Chicago.

'Scenes . . . from which the hand of nature has never been lifted'

The artists who went out into the wilderness and recorded its grandeurs helped create our National Park System, now 100 years old

In August 1870 a small party of men under Henry D. Washburn set out from Bozeman, Montana, and headed south to explore the upper Yellowstone River, an area almost totally ignored by our impatient pioneers in their headlong march to the Pacific. Only Indians, fur trappers and one small expedition had thus far penetrated this wilderness. It was Washburn's objective, as one writer has put it, "to verify or discredit a half-century's accumulation of rumors about fantastic rainbow-colored hot springs where it was possible to hook a trout in one shimmering pool and flip it into a boiling pink and yellow caldron to cook it, a forest of geysers, and huge waterfalls."

The rumors paled beside the reality. And in a campfire discussion toward the end of the expedition, the suggestion was made that the area should be set aside as a national park. This was not the beginning of the park idea; its roots probably go back to the 1830s, and certainly to 1864, when the Yosemite Valley was given to the state of California "for public use, resort and recreation." But Yellowstone, created by act of Congress in 1872, was the world's first *national* park and the reason why the National Park System is celebrating its centennial this year. To commemorate that event, the Smithsonian's National Collection of Fine Arts is currently holding an exhibition of paintings by 19th-century artists who recorded the grandeurs of our wilderness, and thereby strongly influenced public opinion toward their preservation in national parks. As a school of painting, these artists are united less by simi-

Thomas Hill, *Muir Glacier*. John Muir discovered Glacier Bay, Alaska, in 1879. Hill sailed up from California to paint the glacier named for him.

Lent by Mr. and Mrs. Richard R. Hanna, M. H. de Young Memorial Museum, San Francisco

larities of style than by a common approach to landscape which they shared with most educated Americans of the time.

Nineteenth-century attitudes toward nature have been studied with increasing attention over the past decade. Most historians would probably agree that the principal reaction of Americans to their native environment was dependent upon the capacity in which they faced the virgin wilderness—which, by the 1830s, was still in abundance north of Massachusetts and west of the Alleghenies. To many pioneers it undoubtedly remained a bitter foe, but to others more conscious of the destiny of the new nation it was an inspiration out of which they hoped would grow a second Promised Land. Many threads were wound into this vision, and it is possible to suggest only a few here.

William Cullen Bryant was the first major poet to make Americans aware of their surroundings. Bryant was still active in 1872, when he edited the two volumes of *Picturesque America,* but it was his poetry of the 1820s and '30s that had the greatest influence—poems praising nature's power as manifested in the prairies, forests and mountains of the virgin continent. These same two decades saw the creation of the peripatetic frontier character, Natty Bumppo, by Bryant's great contemporary, James Fenimore Cooper. Bumppo's adventures carried him over much of New England's finest scenery, and it was Cooper's description of this scenery that also helped to awaken both Americans and Europeans to the distinctive quality of the American landscape.

Both Bryant and Cooper found a religious meaning in all nature, but they did not attempt to identify God with the material world. This final step was taken by the Concord philosopher Ralph Waldo Emerson, who conceived of Man, nature and God as existing in perfect spiritual unity. According to Emerson, however,

Albert Bierstadt, *Mt. Corcoran* (California). The peak is thought to be a spur of Mt. Whitney.

The Corcoran Gallery of Art, Washington

William Hahn, *Yosemite Valley from Glacier Point.* This sight-seeing party was painted in 1874.

"New Eyes" were needed to study even the most familiar of surroundings: "Go out to walk with a painter, and you shall see for the first time groups, colors, clouds, and keepings, and shall have the pleasure of discovering resources in a hitherto barren ground, of finding as good as a new sense in such skill to use an old one."

American painters did not suddenly discover the landscape after reading Emerson, of course; he simply wrote down a system of ideas that was closely related to their own approach. Their mission, as he expressed it, was to combine what they observed with the spirit in which they believed, to capture the divine essence of each object or landscape they painted.

This concept, however, presupposed continued access to an unspoiled countryside, and Emerson saw the growth of industry in the early 1840s as affecting the traditional relationship between Man and nature. "National preserves" were proposed as an answer in 1858 by Emerson's great follower, Henry David Thoreau: "Why should not we . . . have our national preserves . . . in which bear and panther, and some even of the hunter race, may still exist, and not be 'civilized off the face of the earth' . . . for inspiration and our true re-creation?"

As our environment became better understood, the damage being done by civilized greed became more obvious, and a strong conservation movement was established at the end of the 19th century under the political and spiritual leadership of Theodore Roosevelt and John Muir (SMITHSONIAN, March 1971). As first president of the Sierra Club, Muir led the battle to save Hetch Hetchy Canyon in northern Yosemite Park from becoming a water reservoir for San Francisco. He failed, just as his recent successor, David Brower, failed some years ago to prevent the construction of the Glen Canyon dam on the Colorado River. But Brower's argument, that man must abide by nature's scheme, indicates the debt we still owe to those 19th-century Americans who made us aware of our natural environment.

Virgin wilderness

The first American landscape painter to express these ideas in print as well as on canvas was Thomas Cole. It was the virgin character of America's wilderness, as distinct from the more civilized appearance of the Old World, that Cole emphasized in his now classic "Essay on American Scenery" of 1835. "Those scenes of solitude from which the hand of nature has never been lifted," he wrote, "affect the mind with a more deep toned emotion than aught which the hand of man has touched. Amid them the consequent associations are of God the creator—they are his undefiled

The California Historical Society, San Francisco

Wadsworth Atheneum, Hartford. Bequest of Mrs. Frederic S. Gould

Frederic E. Church, *Sunrise off the Maine Coast*. This was painted on Mt. Desert Island, now the site of Acadia National Park.

Opposite: Titian R. Peale, *Volcano of Kilauea*. The artist painted this vision of Hell in Hawaii with the Wilkes Expedition of 1838-42.

works, and the mind is cast into the contemplation of eternal things."

Cole wrote mostly about New England scenery, but the painter George Catlin had already ventured far west of the Mississippi by 1832. From a bluff high above the confluence of the Missouri and Yellowstone Rivers, he wrote back of his desire "to paint the splendid panorama of a world entirely different from anything seen or painted before . . . where nought but silence reigns, and where the soul of a contemplative mould is seemingly lifted up to its Creator."

The English critic John Ruskin—who asserted that art must reflect man's delight in the creations of God, and that this required a freely naturalistic style—also had an influence on the landscape painters in the last half of the 19th century. Their major canvases were built up detail by detail from closely observed facts, although the final arrangement was often somewhat contrived to emphasize the inspirational effect of the scene. Landscape painting, of course, had always been a contrived version of nature, with artists selecting and ordering the appearance of nature to concur with their individual attitudes.

Albert Bierstadt's desire to paint the Rocky Mountains and Cole's interest in the Adirondacks, for example, had a common source, but their artistic goals differed greatly. Cole thought of the wilderness as a spiritual resource, although he recognized a dilemma: Untamed nature might have limitations as a steady diet, but "cultivated scenery" was inevitably succeeded by the industrial menace. Bierstadt, almost 30 years younger, saw no such dilemma. He understood the economic potential of spectacular landscapes in much the same way that "Manifest Destiny" advocates of the mid-19th century understood the economic resources of the wilderness.

Bierstadt was the first major landscape painter to go west, when he joined Colonel Frederick W. Lander's expedition to explore alternate wagon routes through the Rocky Mountains. On occasion Bierstadt was criticized for his inaccuracies. "He hasn't what old Ruskin calls for," the geologist Clarence King once remarked

The American Museum of Natural History, New York

of one of his paintings of Yosemite. But no one ever challenged the authority of Thomas Moran's equally impressive but less overtly dramatic canvases. Speaking of his *Grand Canyon of the Yellowstone,* he said: "My aim was to bring before the public the character of that region. The rocks in the foreground are so carefully drawn that a geologist could determine their precise nature."

The frequency with which science is mentioned in connection with landscape painting and the appreciation of nature in the last half of the 19th century has only recently come under investigation. The natural history studies sponsored by the American Philosophical Society in Philadelphia at the beginning of the 19th century suggest early connections, which were continued by the traveling artist-naturalists, Alexander Wilson, James Audubon, Titian Peale (above) and George Catlin. But the writings of the great German scientist Alexander von Humboldt had the most effect on our landscape painters. He urged artists and naturalists to study the "varied forms of nature" in the remote and unexplored countries of the world. Only then could they have the proper background when once they settled into a more parochial orbit. Only a short time after the publication of Humboldt's *Cosmos* in this country, the painter Frederic Church went to South America with the grand geography almost literally in his lap. The outcome was *The Heart of the Andes,* a minutely detailed and vastly popular painting of tropical scenery that would have pleased both Emerson and Humboldt.

Much of this esthetic of detail was also determined by the increasing use of photography among artists and scientists in the second half of the 19th century. Bierstadt, Moran, William Keith and other Western painters all made use of photographs as preliminary studies or compositional aids, and there is one painting in the current exhibition that Moran admitted to having done entirely from a photograph.

In the early 1840s Thomas Cole had already urged

upon American landscape painters the task of recording a vanishing wilderness, and several years later this idea was put in the form of a manifesto by a young critic reviewing the early paintings of Jasper Cropsey: "The axe of civilization is busy with our old forest, and artisan ingenuity is fast sweeping away the relics of our national infancy. . . . Yankee enterprise has little sympathy with the picturesque, and it behooves our artists to rescue from its grasp the little that is left, before it is for ever too late."

Landscape painters, then, were to concern themselves with a painted record of the wilderness. But in his solitary ramblings on the prairies in the 1830s, George Catlin had already gone a step beyond this, advocating the preservation of "A Nation's Park" on the Great Plains.

As cities, railroads and steamships began significantly to change the appearance of the East, the need for public parks was more frequently expressed. One of the earliest and perhaps the most influential figure in the movement was Andrew Jackson Downing, a gardener turned landscape architect. Through his numerous and popular writings in the 1840s, Downing attempted to make the public more aware of the general characteristics of American scenery, to instruct them as to how it might be used to embellish more tastefully their domestic surroundings, and to stress the moral and sociological benefits of a life lived in contact with nature. In his later writings he turned his attention to public parks, and he had no small influence on the founding of Central Park in New York.

Although a direct line can be traced from Downing to Yosemite, there is perhaps another aspect of his work which was of greater importance in the development of our parks. His *Treatise on the Theory and Practice of Landscape Gardening* of 1841 is an almost unadulterated restatement of the theory of the Picturesque. Where the English left off in the 1790s, Downing began: "The Picturesque in Landscape Gardening aims at the production of outlines of a certain spirited irregularity, surfaces comparatively abrupt and broken, and growth of a somewhat wild and bold character."

Downing followed this discourse with much practical advice on indigenous trees and shrubs, but basically his message was that the appearance of rural England in the 18th century was the accepted standard of taste. While this precluded the possibility of a landscape covered with factories, it was not exactly the noble wilderness that Cole had written about earlier and that was still a cherished dream of many Americans. What we must understand is that the idea of virgin wilderness as God's creation and the more profane concept of the Picturesque coexisted in this country through most of the 19th century. What Americans really wished to discover, it seems, was a landscape made picturesque by the hand of God—and that is what they found in our first two national parks, Yellowstone and Yosemite.

We must remember that while stressing his wilderness theme, Cole had also expressed an appreciation for cultivated scenery; and Emerson thought we might occasionally "hear too much of rural influences." Henry Adams, on a visit to Estes Park in 1871, noted how "The Park stretched its English beauties off to the base of its bordering mountains in natural landscape and archaic peace; the stream was just fishy enough to tempt lingering along its banks."

Some years earlier, Clarence King had used the word "park" in a description of Yosemite Valley that was straight Downing: "Directly beneath, outspread like a delicately tinted chart, lay the lovely park of Yosemite, winding in and out about the solid white feet of precipices which sank into it on either side; its sunlit surface invaded by the shadow of the south wall; its spires of pine, open expanses of buff and drab meadow, and families of umber oaks rising as background for the vivid green river-margin and flaming masses of frosted cottonwood foliage."

Obviously, to King the landscape of the park did not look "wild"; it was virgin wilderness shaped by centuries of geologic change to suit the spiritual and esthetic needs of 19th-century Americans. To this were to come Emerson's tradesman and attorney "out of the din and craft of the street" to be made whole again. "The health of the eye seems to demand a horizon," he wrote. "We are never tired so long as we can see far enough."

Thomas Moran, *Looking up the Trail at Bright Angel, Grand Canyon of Arizona*. An uncompleted sketch in watercolor and gouache, with penciled notations on the colors to be used in the foreground.

Cooper-Hewitt Museum of Decorative Arts and Design, Smithsonian Institution

An advertisement for itself, this tropical moth *(Histiaea meldolae)* avoids harm by being visible. Predators learn such moths are bad-tasting.

Photographs by Kjell B. Sandved
Comment by Michael Emsley

The ostentatious and the obscure

Brilliant colors, disguises and cryptic patterns of moths and butterflies are reminders of the intricacies of evolution and the passage of time

When he wrote "Leisure" at the beginning of this century, the English poet William Henry Davies was already troubled by the accelerating pace of life:

What is this life if, full of care,
We have no time to stand and stare.

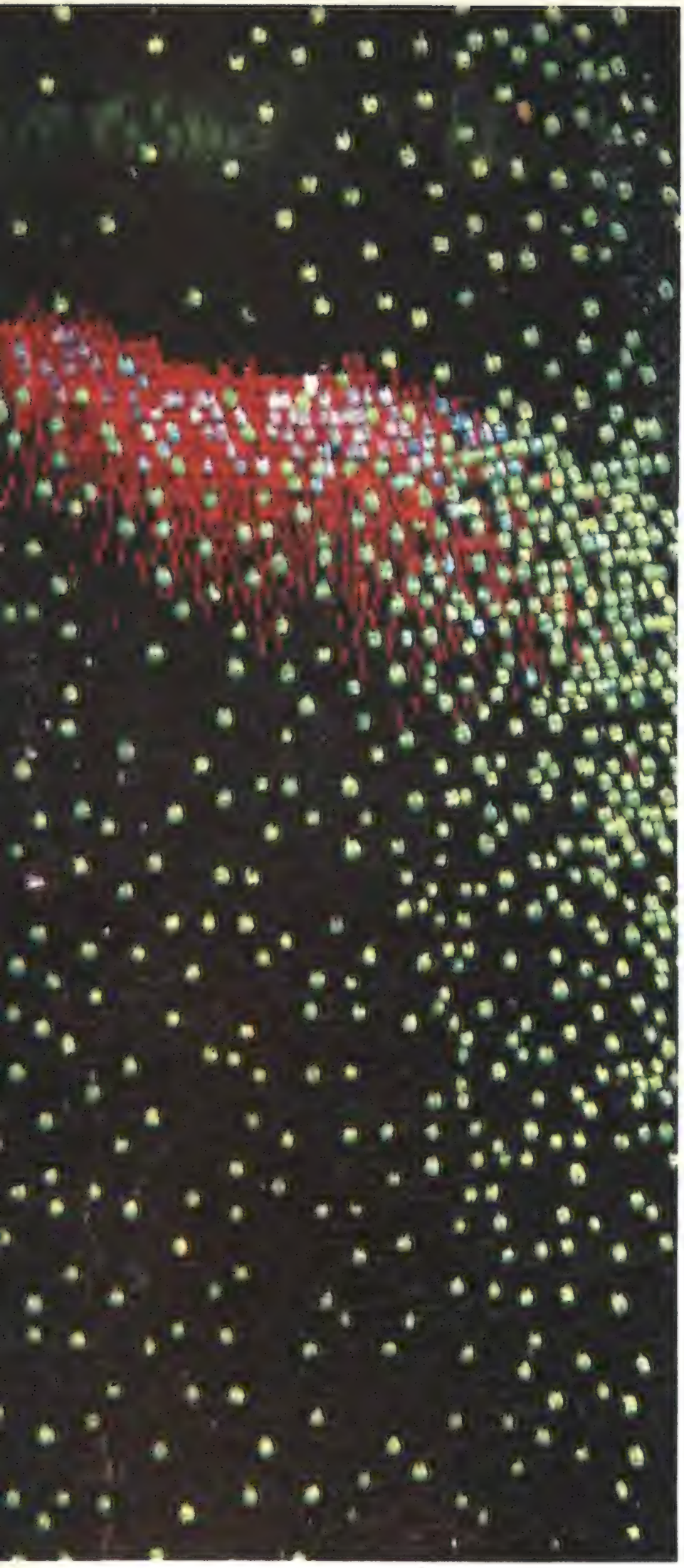
Were Davies alive today he might find difficulty in choosing words to express his feelings at our pell-mell rush to fulfill our destinies.

The professional biologist is rarely an exception to our frenzy. He, too, has his goals, his deadlines and his frustrations, yet he, of all people, should have time to stand and stare.

The naturalist William Beebe took the time. His ramblings around the world exposed many exciting biological puzzles and sparked the investigative fire of many researchers. At Rancho Grande in tropical Venezuela, a major migratory pass for a host of animals, Beebe reported a moth which hangs by the front feet during the day. It twirls in the wind, but when it is disturbed by an inquisitive predator, the moth escapes by falling to the ground.

Every biologist should experience the richness of the

At Venezuela's Rancho Grande, photographer Kjell B. Sandved's lights attract moths and other night-flying insects in abundance.



Photographed at extreme close-up, these scales, the basic units of wing color and design, seem more like "streams of stars" than butterfly markings.

tropics, where proliferation of species is the rule. This dictates a diversity of strategies for survival. Deception in form, in color and in behavior abound, to eat or to avoid being eaten. Every species fills a niche, every niche is a complex of competition. Tropical butterflies and their thick-waisted relatives, moths, are spectacular examples of these intricacies of evolution and natural selection. But with sectarian interests growing in the world, even a biologist's opportunities—and time—to linger in the tropics are dwindling.

No time to see, in broad daylight,
Streams full of stars, like skies at night.

How many of us pause with hand lens or microscope to look and marvel at the scales on a lepidopteran wing. Each perfectly formed to disseminate scent, to maintain an airfoil for flight, or just to contribute to the color pattern of the whole. Listen to that last phrase once more: just to contribute to the color pattern of the whole.

Ponder the mechanism that determines that a particular scale will be yellow, black, red or white to act in concert with a thousand others to simulate a vertebrate eye. How startling for a hungry bird, probing bark for insect food, to be presented in a flash with a pair of eyes, only to be alone again.

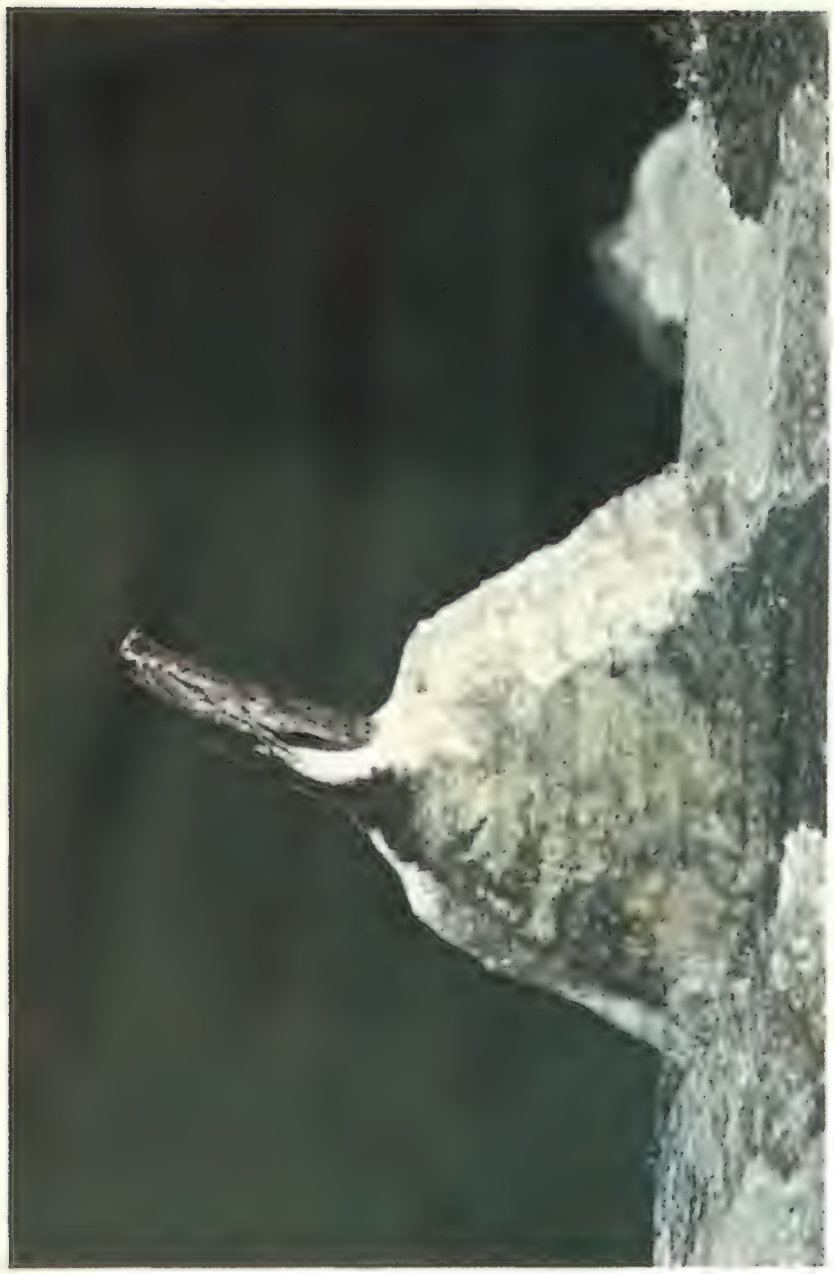
Animals on Earth today are the survivors of three billion years of competition between predators and prey, between detection mechanisms and protective devices. The unsuccessful are now extinct.

Think of the evolution of sonar in bats for navigation and location of prey in the dark, and the adaptation of some arctiid moths which emit similar signals to avoid being caught. Think of the visual acuity and learning ability of birds and the protective coloration of insects. When we see a conspicuously colored insect, like the moth on page 42, we should question why has it not been eaten. Perhaps it is bad-tasting, or perhaps it has a color pattern that resembles an insect that is bad-tasting. It is then an advantage to be seen, to advertise, to warn.

The color pattern of day-flying insects is a compromise between conspicuity to find a mate and concealment to avoid predation. The nocturnal moth usually seeks its mate by odor, and its cryptic pattern gives protection by its resemblance to inedible objects like bird excrement, bark, thorns, twigs or a dead dry leaf. However, it is not enough that the moth evolves a cryptic pattern, for it must also behave appropriately. It must alight on a suitable background or the deception will be lost.

Kjell Sandved is a photographer and producer of biological films in the Smithsonian's Museum of Natural History. Michael Emsley is professor of biology at Virginia's George Mason University.

The elaborate pattern seen on a wing of the moth *Grasellsia isabella* seems like a big eye that blinks open suddenly, startling a would-be predator into flight.



A Venezuelan moth of the family Gelechiidae not only looks like a twig but must know where twigs grow.

How does the moth know what to do? Does it learn? Is it instinct? Prior to the middle of the 19th century the peppered moth *(Biston betularia)* was light colored and rested by day well camouflaged on light lichen-covered tree trunks, fence posts or rocks. Dark forms of the peppered moth occurred here and there: genetic rarities. Such was the case in Manchester, England, when industrialization began to veneer all resting places with soot. But from 1895 to the present time nearly all the *betularia* moths captured in Manchester and other industrial towns have been dark ones. This is the classic case of "industrial melanism."

Prior to the Industrial Revolution the dark variety was disadvantaged in that it was conspicuous and was easily detected and eaten by birds. Since then the light variety has been all but eliminated. It is the darker form that now is inconspicuous. Will the results of our environmental concern restore the dominance of the lichenlike form? It could happen in 50 years. If only we had time to study problems such as these.

No time to turn at Beauty's glance,
And watch her feet, how they can dance.

Consider the scientist's recent thrill at demonstrating that butterflies can hear. But consider also that a German naturalist thought they might and correctly suggested how they could—in 1812. One must respect the investigators of earlier centuries who had inferior equipment and limited knowledge. But remember, they had time. Time to observe and, more important, time to think.

Contemplate the special scales with which some moths lock their wings together, precursive to the safety pin by several million years. The operation of this device is manifest at a glance, but the use of many structures is not. As our understanding improves we find that more and more "functionless" features are only indicators of our own ignorance. What then is their use? Why do animals do what they do? Why does Beebe's moth hang by its front feet and twirl in the wind? Only given time shall we know.

Kjell Sandved is not a biologist; but as a photographer and film producer at the Smithsonian he has made many trips to the tropics—and elsewhere. He takes time to observe such things as moths and butterflies, and because he records them through a lens, those of us who are entrapped in our own goals and frustrations are reminded of the need every now and then to stop and look.

A poor life this if, full of care,
We have no time to stand and stare.

Most predators—and people—would pass by this dead leaf, not knowing it is a moth of the genus *Antaea.*

A moth of the family Eucleidae hangs from lichen, twirling in wind. When disturbed, it drops.

Smithsonian exhibit

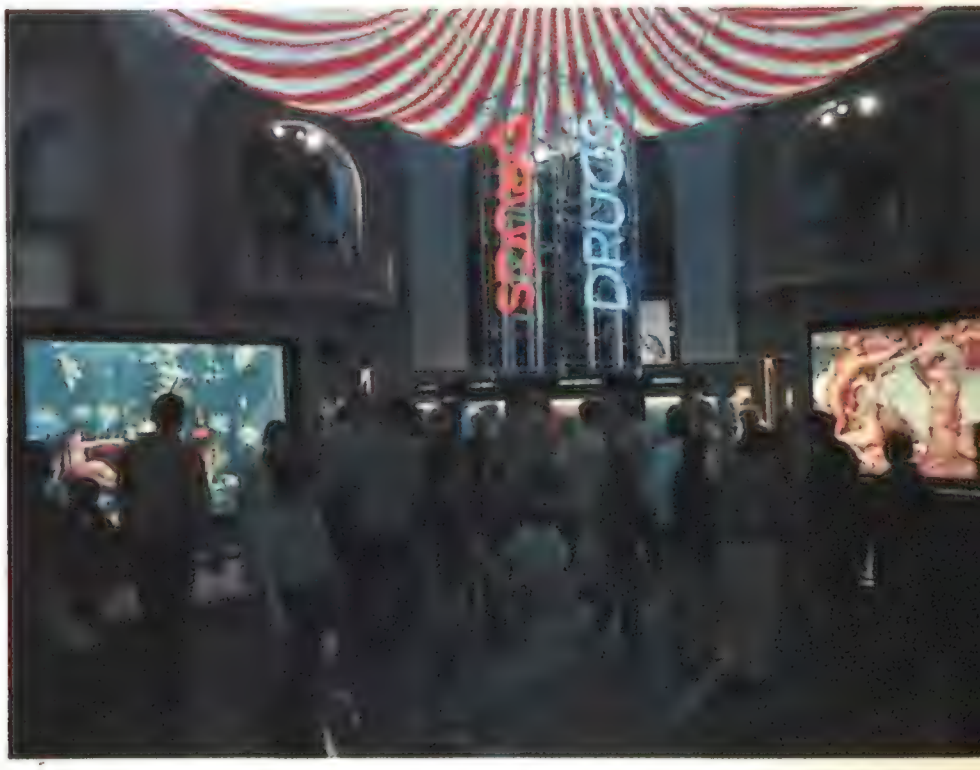
The drug scene now and then

Uncle Sam smokes. He smokes almost anything, drinks booze, pops pills, shoots up—and has for generations.

With a penchant for utopian visions, fueled by fast-buck hucksters, American society has historically sought anything from relief to nirvana along a continuum of bromides that runs from a cup of coffee and

Visitors can sharpen up their drug vocabulary by guessing at such slang as "shoot up" (right) from clues.

In the Theater of Talking Heads, a plastic "ex-addict" subjects visitors to a monologue.

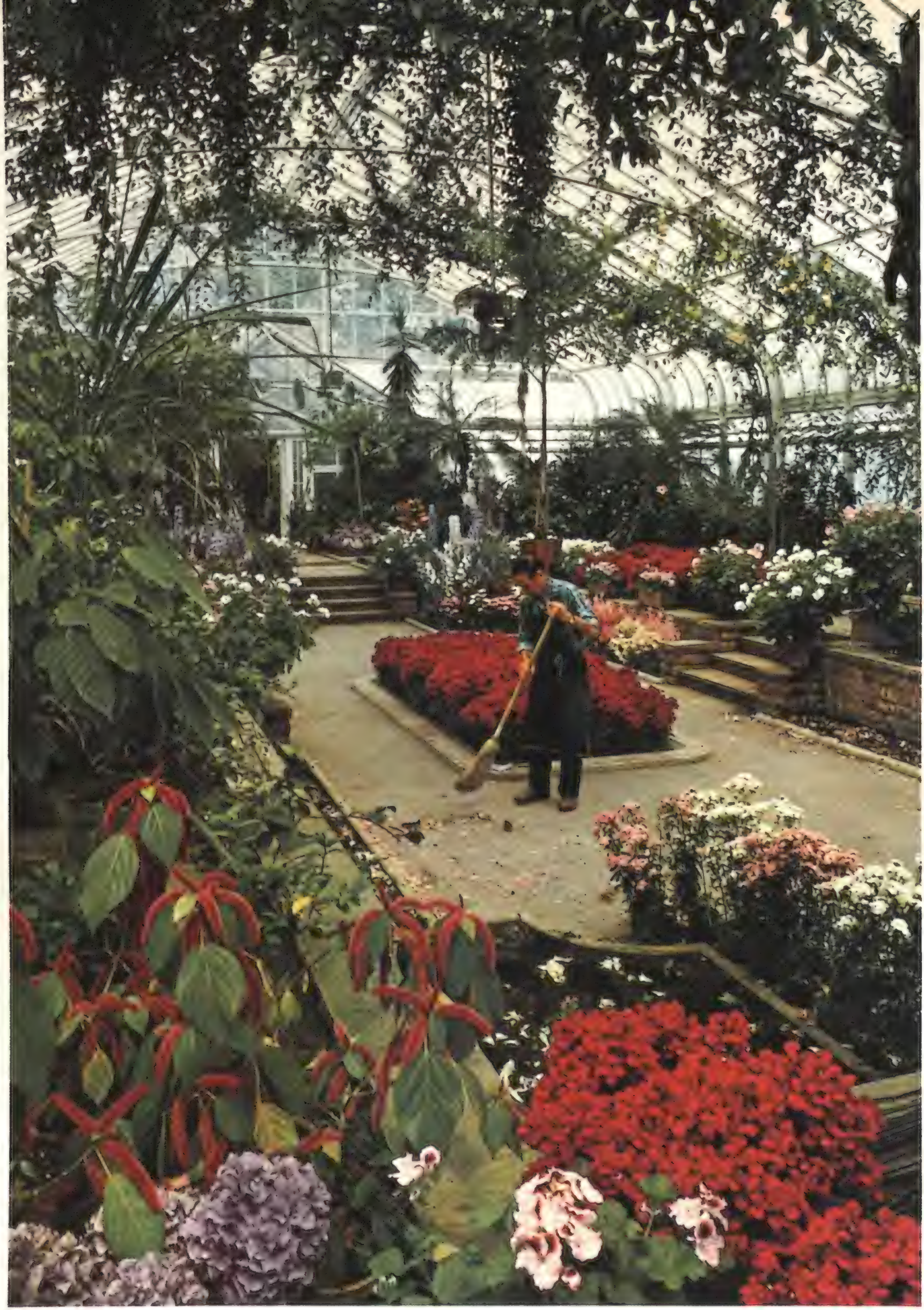


Visions of edens lost and gained by Michelangelo and Rousseau flank neon-lit vending machines.

headache pills to a syringe of horse in the forearm.

Such is the message of *Drugs: A Special Exhibition,* hammered home by a sometimes bewildering array of pop-art caveats, old posters, a huge inflated bubble house filled with photographs of the drug scene and five animated dummies, plus a lively rap theater populated by real singers, ex-addicts and seminar leaders.

And like those old patent-medicine peddlers, the direct ancestors of both today's pusher and today's pharmaceutical corporation, the exhibit is mobile. It is collapsible, foldable: *Drugs* will leave town to travel the nation in 1973.



Huge main greenhouse at Planting Fields Arboretum
has changing displays. Here, hydrangeas and calceolaria.

By John and Joan Neary

Lovely arboretum gets a reprieve

This millionaire's estate is open again to seekers after peace and beauty. But its long-term future use is still in doubt

Living out near its headwaters, we have learned that the Long Island Expressway, that treacherous Niagara of steel and carbon monoxide, might just as likely crawl to a halt at two in the morning as at the evening rush hour. And where a picnic-bound family, as ours often is, could be reasonably sure ten years ago of finding blanket space on the sand even on Labor Day, the causeways to the beaches now back up for miles, long before noon on any rainless Sunday. We expect lines at museums, crowds at zoos and aquariums, so the quest for surcease from "civilization" has become almost as difficult and stressful as the elements we are trying to escape in the first place. We learn, therefore, to cherish those few remaining places of sanctuary that we have been lucky enough to discover.

For our family, Planting Fields Arboretum was such a place. Visiting Planting Fields, not far from our home on the North Shore of Long Island, meant turning off the ever-crowded, hurry-up standardized present for as long as a day of strangely healing absorption in its sheer loveliness. We suffered when it closed for lack of funds. Now it is open again—it is operating at least for this year.

We discovered Planting Fields several autumns ago. The route was a winding stretch of tree-canopied blacktop near Oyster Bay, through a Sound frontage right out of F. Scott Fitzgerald, past picket-fenced estates with names like *Xanadu*. It is a road well-traveled by bicyclists, children on horseback, more than one Rolls-Royce and a gaudy, ghostly, boat-tailed Bugatti that thunders by on especially fine Sunday mornings. That first day we passed the majestic iron formal entrance gate—locked, apparently, to any vehicle except perhaps a Silver Ghost or, at the very least, a Packard straight-12. We drove on to the Arboretum's public entrance, found the uncrowded parking lot, and walked onto the gravel paths of the Synoptic Shrub Garden, so named because it contains a synopsis of the deciduous and evergreen shrubs considered most desirable as ornamentals for the gardens of Long Island and Greater New York.

There in sun-dappled profusion were 400 different species and cultivars of flowering plants, arranged over a five-acre area, in alphabetical order from abelia to hydrangea to pyracantha and wisteria. Beckoning just outside the border of the garden lay the gentle greensward, stretching to the gargoyled sandstone mansion and, beyond, to open meadow. Here our three boys could run to the limits of their taut energy with no policemen to blow whistles, no crowds, no signs prohibiting and forbidding. Unhurriedly, we came upon hidden gardens, and discovered caricatures lovingly carved on the ends of beams jutting through carved sandstone walls.

We marveled at the collection of some 7,000 orchids worth untold thousands of dollars. Orchid curator Frank Griechen told us that one bulb alone of his cymbidium might cost as much as $250. "I have a better collection of Brazilian orchids than they have in Brazil," he said.

In a greenhouse next door, Griechen introduced us to Mrs. Louise Lippold, a dancer, married to the sculptor Richard Lippold. Mrs. Lippold told us how, in 1966, on a trip West, she was beguiled by cacti, decided to learn all she could about them and became full-time volunteer cactus curator of Planting Fields.

Over the next few years we came to know a bit about the complex man who built Planting Fields, millionaire William Robertson Coe, who gave his 409-acre estate to the people of the state of New York in 1949 and who lived on it until he died in 1955. Coe loved land. In addition to Planting Fields, he owned 200,000 acres near Cody, Wyoming (it was formerly the ranch of Buffalo Bill Cody), a plantation in South Carolina, an estate in Florida as well as his Manhattan duplex. He loved, too, to embellish his land with horticultural adornments.

Perhaps the Long Island farm country sparked some recollection of his native Worcestershire. He left England with his family as a very young man and became

John Neary, a senior editor of On the Sound, *wrote an article on a 16-year-old town historian for* SMITHSONIAN, *just a year ago. His wife Joan took these photographs of Planting Fields.*

Coe Hall, home of the late William Richardson Coe, stands among spacious lawns and bright gardens.

Fourth graders from a Commack, Long Island, school explore the floral wonderland of the Arboretum.

an office boy for Johnson and Higgins, a New York insurance company. By 1910, at 41, Coe had become president of the firm and was looking for a fitting residence. Between 1919 and 1921 he built the 75-room mansion he called Coe Hall as the centerpiece of the estate he had stitched together out of North Shore farms. He retained the name Planting Fields—what the Matinecock Indians had called this spot where they raised their crops.

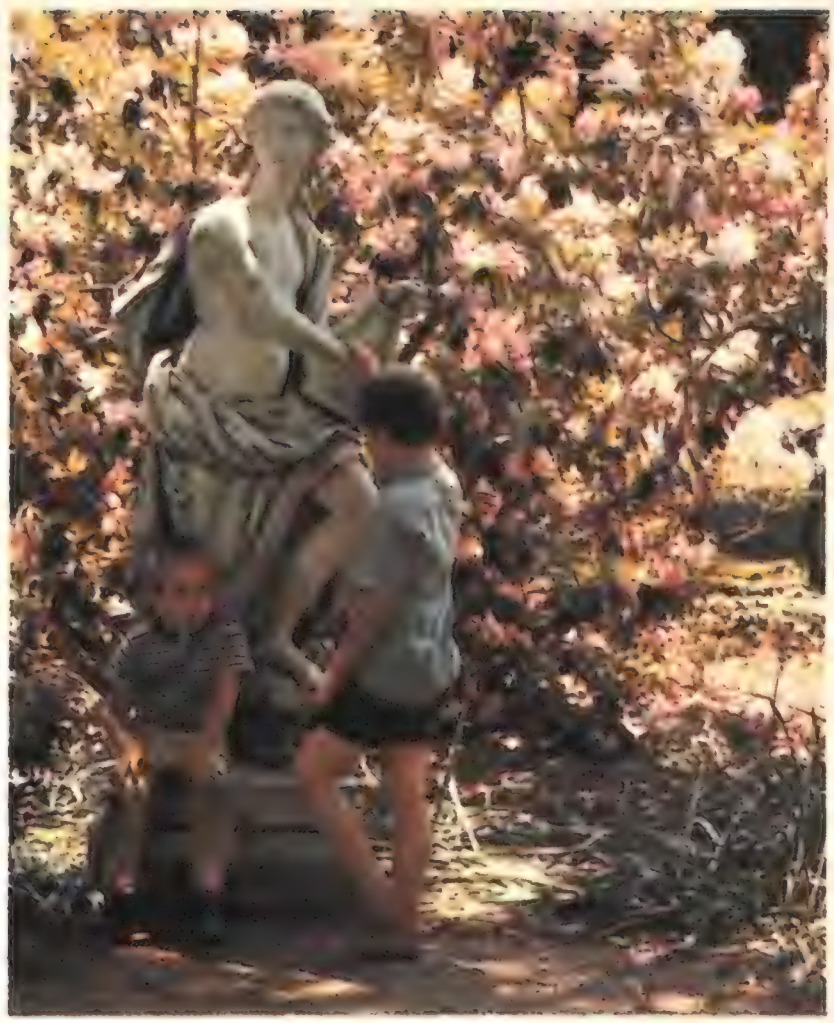
To landscape his estate, Coe hired Olmsted Brothers of Boston, and ordered shipments of rhododendron from a nursery in England. On the estate of his father-in-law, financier H.H. Rogers, in Fairhaven, Massachusetts, there flourished a magnificent 30-foot-high copper beech that Coe had a yen to see shadowing *his* lawn. Moving it posed a tough problem. Coe hired 72 horses, hostlers, a steamroller and a barge to carry the tree across Long Island Sound. The enormous weight of the 12-foot rootball all but sank the barge, but Coe got his tree.

A passion for cunning detail manifests itself in the myriad intricacies of the mansion. A wall panel swings ajar at the touch of a secret button in Coe's study to reveal a walk-in bar; another panel in a dim corridor off the entrance hall is the hidden door to an elevator—which has one stop at a secret room between the first and second floors, provided for books and storage.

Each major bedroom (a total of eight) had its concealed wall safe. In the mansion's cavernous basement is a boxcar-sized, walk-in vault behind whose spoke-wheeled steel door Coe kept his wines. Coe adorned his home with stained glass, delicate carvings, handsome wood frescoes depicting Plains Indians, all accouterments that a self-made millionaire could conjure up for his own delight and, it turns out, for ours.

His portrait hangs in the entry hall: smooth, pink face, pearl-gray riding outfit with crimson vest, pearl cuff links and stickpin in white silk tie, gloves and silver-tipped riding crop. Coe switched allegiance from Rolls-Royce to Cadillac for his visits to New York (longer journeys were by private railcar) only with reluctance. And he did not hesitate to get Alfred P. Sloan, head of General Motors, on the phone for some proper British hell when the Cadillac's low roof persisted in knocking Coe's hat off. On the other hand, he would reprove his secretary of long standing for not using clasp envelopes more than once, for profligacy with paper clips, for burning lights on sunny days and for splurging on cables when an ordinary letter would have arrived in time.

During the time the estate was being developed, Coe had two dozen servants tending the household and 200 men working on the grounds of his estate. When he opened it to the public in 1949, he would join visitors



Small visitors make friends with a statue among the rhododendron. It once greeted only millionaires.

on their walks across his grounds. He knew every tree.

Coe wanted everyone to enjoy the experience. And so we did. Not that Planting Fields was totally untouched by society beyond its gates. There were turbulences that Coe could scarcely have foreseen–youths who wandered the tidy paths with a look that belied their flower-children costumes. More than once my boys fetched back hashish pipes which they found tossed off in the underbrush. Policemen appeared on motorized carts to shush the guitars, ground the Frisbees, shoo the dogs and eyeball the disciples of Consciousness III. One day we arrived to find a gatehouse with a guard collecting a stiff admission fee. On a subsequent visit, we found, just as mysteriously, the gatehouse burned to the ground. Not long after that we found the gate locked. Planting Fields was closed to the public.

We missed it badly. We assumed the kids had been too troublous to cope with. Then, one day last winter, as we waited to pay for a potted Christmas tree not far from Planting Fields, I spotted a stack of fliers beside the cash register. Planting Fields was asking for donations "to help meet the current fiscal emergency." After all of Coe's efforts to build a place of beauty, and to share it with the public, to be undone by some pinchpenny problem he could have solved with a few phone calls!

We decided to investigate. We found Gordon E. Jones, director of the Arboretum, in his elegant office in the "cottage," a mini-mansion that Mrs. Coe built after her husband's death. Mr. Jones was self-conscious about the opulence of his surroundings in view of the fact that Planting Fields was broke. Rather, the state of New York was broke—or close to it. Mr. Jones was having problems just managing to keep the greenhouses heated.

While we had been enjoying ourselves, we learned Planting Fields had been moving steadily toward its crisis. Coe's son, William Rogers, administered the Coe Foundation until his death in 1971, which left the Arboretum without any powerful political angel to look after its fortunes, making it a mere stepchild of the state's huge university system. First it was a horticultural school connected with a local campus, then a conference center, most recently the site of the State University College at Old Westbury, where the curriculum tended toward sitting under trees. Last year, when the College moved to its new quarters, the Arboretum found itself no longer part of the university system, but an adjunct of the state's park system. (Images of swings and seesaws, swimming pools and hot dog stands flashed through the fearful minds of Planting Fields' admirers.)

As the bookkeeping switch from university to parks

was made, weary state legislators, at the end of an exhausting budget session, simply neglected to appropriate money to operate the place for the rest of the fiscal year, a period of nine months. After the oversight was brought to their attention, the forgetful legislators came up with half the money needed to maintain Planting Fields.

Friends rallied. A newsletter formed Friends of Planting Fields. A music recital, a regional magazine story, direct appeals—all had an effect. Alexander Aldrich, New York State's Commissioner of Parks and Recreation, announced he was making the reopening of Planting Fields "just about my number-one priority," and with the support of many civic-minded people proceeded with a request to the state legislature and budget office for $402,000 to help do it.

A few months ago, the New York legislature acted on the budget, doing so at a time when there hardly seemed enough money for adequate hospital care in the Empire State, much less money for a place where one bronze downspout alone cost $8,000 and where the only commodity being offered the strained taxpayer was some ephemeral intangible called *sanctuary*.

"I feel we are keeping the people from a priceless resource," Aldrich told me, saying that the value of the Arboretum as a respite from the pressures of modern life was every bit as documentably valid as any proposed hospital budget. Still, it *would* reopen, only five days a week instead of seven—with an admission charge of $1.50 for adults—but only from May to October.

That was this year. We are faced with a similar crisis next year, and the year after that. . . .

Shaded walk threads riotous azaleas, some of the hundreds that have made Planting Fields famous.

By Michael Schofield

For a lobster what's vital is how things–and other lobsters–smell

In a world they know mainly by sensing its chemical makeup, many marine creatures may be especially vulnerable to pollution by oil.

The lobster, that gourmet's delight and essential component of any vacation on the New England coast, may also prove to be an effective early-warning system for marine pollution.

Virtually anyone can tell when the most dramatic kind of pollution—a catastrophic oil spill from a tanker or an offshore oil rig—has occurred in local waters. Birds and foolhardy bathers can be covered with black sludge; beaches can be ruined for years. Yet the long-term implications of oil pollution for the marine food chain are still largely unknown.

There may be subtle, low-level effects and it is at this point that the lowly lobster, creeping along the bottom like an oversized, armored insect, comes into the picture. For it is widely feared that tiny amounts of oil, far below the immediately toxic level, may severely interrupt the complex and fragile environment in which such marine organisms feed, migrate and spawn.

Sharing this alarm is a team of young oceanographers at Woods Hole Oceanographic Institution on Cape Cod. Led by a 33-year-old Canadian student of animal behavior named John Todd and a 31-year-old Dutch-born biologist named Jelle Atema, the research team has been studying animal communication for the last two years. Specifically, they are interested in how such creatures as lobsters, catfish and herring communicate with each other and with their environment by means of chemicals.

"For us, as humans," Atema explains, "vision is most important in the process of communication. Our thinking is most affected by seeing and hearing. Smell and taste are less developed. For many animals it can be different. Take a dog. How does it know when you're scared? It doesn't see very well, but it can smell your chemical 'aura.' Some animals are even more nonvisual or use entirely different sensory systems.

"Some animals can produce certain chemicals as they wish," says Atema, "and each chemical can have a certain meaning. It's like waving a flag." Little is known, however, of chemical communication among marine animals because, among other reasons, the ocean is such a difficult habitat to study. Todd and Atema and their fellow researchers at Woods Hole have constructed small marine ecosystems for observing the behavior of their animals and for attempting to measure the effects of pollution on the animals' chemical environment.

The first step in understanding an animal is simply to watch it. "When you watch lobsters closely," says Atema, "you can see transparent hairs between the protective row of stiff guard hairs on the short antennae. Those hairs probably correspond, respectively, to the senses of smell and touch for a lobster and process information to its brain. We vaguely feel the wind but it is not like the very precise and exact feeling that a lobster experiences from a water current. The lobster can analyze in great detail the information contained in the water movement about him." This is a mechanical sense, but chemical senses complete the picture. "They may enable the animal to detect the species, sex, and even the mood of another animal."

In the early stages of their research, the oceanographers created different situations for their lobsters and recorded them on film: The chief actor was a par-

Formerly a newspaperman, Mr. Schofield is employed by the Woods Hole Oceanographic Institution.

With tiny (here invisible) hairs on its short antennae,
a lobster assesses small changes in its watery world.

Female lobsters emit a chemical that suppresses male aggression and brings about an amorous approach.

ticular male whom they named "Super Stud." When Super Stud was introduced into a tank occupied by a female, a claw fight ensued with the female eventually submitting. In a second instance, Super Stud wound up in a fight with another male.

Atema had earlier discovered that a just-molted female emits a sex pheromone which suppresses the male's aggressive tendencies and, instead, attracts him. When the sex pheromone was artifically introduced into the water, it was ignored by a female lobster, but caused the male to search the tank with occasional mating-dance movements. When the researchers put a food extract, clam juice, into the tank, both female and male lobsters immediately responded, grabbing the tube which carried the extract, and trying to eat *it* as well as the clam juice.

These early observations indicated the wide extent to which the lobster relies on chemical information: The scientists' studies with bullheads, a form of catfish, illustrated the point even further.

The whiskers on a catfish are densely packed with taste buds from which nerves carry information to the brain. Other taste buds are located on the gill arches. The continuous flow of water over the gills also reaches these taste buds so that the fish is constantly aware of the complete chemical composition of its environment.

"Just before I came to Woods Hole from San Diego," Todd said, "a graduate student and I found that the catfish we were studying were normally very aggressive. In some instances, they were capable of killing each other in the conflict. But when we increased their numbers in the experimental tanks to a certain point, aggression ceased. A subsequent investigation found that at a certain population level, they started to produce chemicals which inhibited aggression in the community. They all rested on top of one another in a form of communal bliss.

"We were even able to pump these anti-aggression substances into the low-density aggressive and territorial communities and induce a 'love-in' among the formerly nasty territory holders. However, when the interjections were temporarily discontinued, the fish reverted to their aggressive behavior within 24 hours."

In catfish fights, Todd has found, the loser suffers a loss in stature. His growth is retarded even though normal feeding continues in his tank. "A few months after the fight, it is hard to believe that at one time the loser and winner were about the same size."

In another situation, two bullheads had divided their tank into territories. When threatened by means of a chemical signal—the introduction of water from the tank of a larger bullhead who had previously attacked and beaten both of them in conflict—they fled and hid together, disregarding their respective territories. "The memory of the attacker's chemical signal stayed with them for months, whenever water from his tank was introduced into theirs," said Todd.

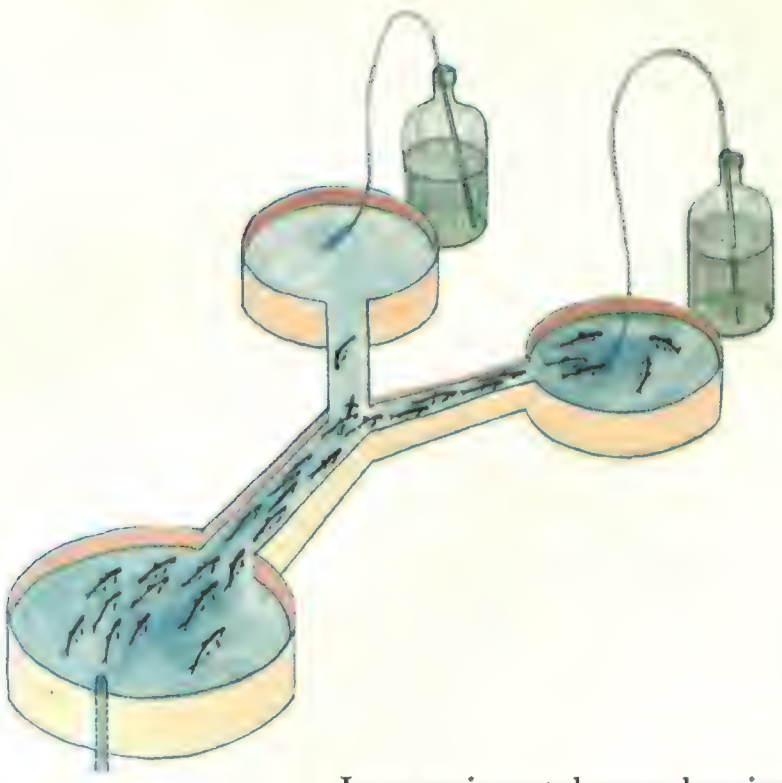
Todd believes the chemical language of the bullheads is amazingly complex. As an example, he talks about the recognition of a loss of status of one bullhead in relation to another. When a fish which had dominated others was placed in a tank where it lost a fight, then was reintroduced to its former tank, the other fish no longer fled. In one instance, a formerly submissive tank mate detected the change in status and attacked.

The point is that an animal can communicate with its environment in many ways—through smell, taste or touch as well as through sight and sound. "You can *see* the yellowish deposits from the Amazon River 200 miles out at sea," he says. "There are other aspects that we can't see that may go much further. Each is a possible agent for communication."

Following a chemical "fingerprint"

Communication on such a plane can be highly sophisticated and can take strange, strong forms. It is a dramatic sight to see a herring run filled with great numbers of the fish leaping through the water, trying to return to their birthplace, knowing that a particular lake, and none other, is home.

In the course of the team's herring research, an experimental stream with a Y-maze was constructed which produced intriguing results. When presented with neighboring stream water in one leg, and home-stream water in the other, the herring most often made the correct choice and congregated in the home-stream leg. "This indicates that the home-stream water contains a chemical 'fingerprint' recognized by the fish, which guides them to their spawning



In experimental maze, herring followed the chemical imprint of their home-stream (right), ignoring the water from another stream.

grounds," says Atema. Considering the stress to which the animals were subjected prior to and during the experiments, the fact that they detected and responded to their home-stream water in the majority of cases is quite extraordinary and a tribute to their incredible ability to detect environmental clues."

The research team of seven persons is expected soon to increase to ten, following recent funding from the National Sea Grant Program and the National Science Foundation (earlier backing had principally been from two private foundations). The scientists break down a problem into different components, such as removing a substance from seawater without destroying it, putting it through chemical isolation procedures, and testing its effect on lobsters. While one person deals in organic chemistry, a second may focus on biology while a third deals in sensory physiology and brain research. Currently within the group, for example, Lauren Stein is studying oil effects on lobsters, Stewart Jacobson is dealing with the social behavior of fish, and David Engstrom is conducting research on herring and catfish. "We have the system almost full circle," said Atema. "Input—chemicals; output—behavior; and the central connection—how one is translated into the other—the brain."

The beginnings are fragile, but the study, with its immediate relationship to man's pollution of the sea, is open-ended in its implications. "The ocean is like a soup of chemicals," said Atema, "including the man-made chemicals, many of them pollutants. They must have an effect on this environment, but no one knows to what extent. Translated into our visual world, a pollutant introduced by man may be like a curtain of smoke—if not an outright curtain of poison. The chemicals in the water that convey this information may be effective in very low quantities.

"We are looking at an early monitoring system," he continued. "It *is* possible that certain pollutants could make it impossible for marine life to communicate. The lobster's sex pheromone, for example, might be destroyed, suppressed, or mimicked by pollution. It may become impossible for the lobster's sensory hairs to do their natural job. The equivalent effect could be to blind a human."

The Woods Hole team is studying the lobster sensory hairs through an electron microscope, magnified thousands of times, in an attempt to see if the oil has any specific effect on these receivers. "We don't know yet," said Atema, "but it definitely affects their behavior—for example, eating—even in the range of a few parts per million."

The oceanographic community has begun to realize the urgency of acquiring a knowledge of how marine animals communicate. "This is no longer purely an academic or scientific matter," says Todd. "The 'languages' of animals are the means whereby they organize their lives in relation to each other—just as we do. Their communication is crucial to their survival, but the 'languages' of fish and other marine creatures probably represent the weakest link in their life histories. Their signals can be jammed or disrupted by extremely low levels of pollutants, and this could have a catastrophic effect on their social behavior.

"What I am saying is that insidious levels of pollution can alter social behavior in such a way as to prevent there even being a next generation. The animals in question will appear healthy, as they are not experi-

Once defeated, a catfish gains the chemical aura of a loser and may well be attacked again.

encing lethal levels of pollution, and ordinary toxicity studies wouldn't indicate that they are in danger. But this would be an illusion. Key signals between mates may have been interfered with, or the bond between parent and young snapped by a toxin, leaving the young to be preyed upon instead of cared for."

Even in the earlier stages of research, the study went far beyond the theoretical stage. At the bottom of some of the tanks housing the lobsters at one Oceanographic Institution laboratory, some kerosene-soaked bricks were deliberately introduced into the watery environment. Some fishermen use this as a technique for baiting lobsters despite its illegality. It is not known why the bricks soaked in kerosene attract the lobsters, but they do, and are about 60 percent as effective as fish bait while being a lot cheaper. The Woods Hole group has watched the kerosene-soaked bricks cause the lobsters to increase their aggression on the one hand, or retreat on the other and, in some cases, compulsively clean themselves. When a few drops of either kerosene or oil were introduced into the tank, one lobster did not eat for a week. A related experiment showed even more grave implications: When a few drops of kerosene were placed on absorbent strips, the animals were attracted to and actually ate them. If these laboratory findings are reflective of the real world, since lobsters are attracted to kerosene and eat it, an animal living in or near an area polluted by oil could become contaminated and unfit as a food source. Furthermore, the oil spill area could conceivably act as a magnet, attracting lobsters to it.

Aside from threatening the marine food chain, what and how the animals eat may be very important to Man on a long-range basis. Our growing population requires new sources of food, and there are several current experiments in farming the edge of the sea and managing marine stocks.

"A knowledge of the behavioral ecology of a species and the signals it uses in communication might just provide the foundation for a sophisticated science and business of aquaculture," says Todd, "as sophisticated and efficient in its own way as some of the more ecologically adept agricultures are today." He believes that both chemical and acoustic signals could be used selectively to help harvest marine stocks, save threatened marine populations, lure fish to seaside nurseries or induce breeding.

He mentions the herring stream as a case in point. "When the chemistry of the stream fingerprints are understood, it will be a relatively easy task to manufacture synthetic substances of a similar nature. If we reach this point, then new methods of managing migratory fish can be developed. An oceanside farmer, or more accurately, a rancher, could use chemical beacons to attract mature stocks. He could collect and market the adults after stripping them of their eggs and sperm for culture purposes. The young would be hatched artificially, conditioned or imprinted to chemical clues by the rancher, and released to the ocean to graze for several years before returning to their artificial breeding site. They would be guided through the final stages of migration by imprint chemicals bled into coastal waters. It may not be too farfetched to suggest that one day each ocean rancher will have his own chemical 'brand,' attracting only *his* stocks to *his* sites along the coast."

For now, however, we are faced with the specter of ugly slicks formed by millions of gallons of oil flushed from the bowels of tankers and the doomsday vision of brown-stained beaches littered with small, limp forms of extinguished life. These are the more popularly conceived images of marine pollution. And oil production and shipment will continue, with the inevitable accidents, despite a lack of knowledge of the effects of pollution, effects which are little discussed because they are not known, effects which are not seen because to us their occurrence is invisible, and thus distant and far removed. But much more immediate, much more at hand is the presence of an undersized lobster, crouching in the back of a water-filled tank, refusing to eat in a small laboratory at Woods Hole. The movement, or lack thereof, of a tiny sensing hair confronted by an infinitely small molecule of oil may have immense implications for humanity.

In this electron microphotograph, the lobster's sensory hair is seen in cross section. Salt water can pass through laminated outer wall (right). Inside, "smell" cells (round objects that are cylinders running the length of hair) capture molecules from the seawater.

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Book reviews

The Roots of Civilization
Alexander Marshack
(McGraw-Hill, $17.50)

This book sets out a totally new interpretation of the meaning of heretofore mysterious cuts and marks found on stones and bones in the Upper Paleolithic of the Old World. These same artifacts have been puzzled over by prehistorians from the time they were found, some more than 100 years ago. Thanks to Marshack's patience and skill, we have at last the keystone to the reason why Upper Paleolithic man, or modern man, advanced so rapidly towards civilization. The result here is a marvelous breakthrough in our knowledge of prehistory.

Thinking man, as far back as 30,000 or 40,000 years ago, learned how to break through the constricting environmental bounds which limited his less-endowed predecessor, Neanderthal man. In understanding the sequential changes in the lunar shifts and noting these on a portable object (and later with accompanying art and symbolizing figures), Upper Paleolithic man gained possession of an instrument more powerful than any weapon. With the notational system, which he used like a kind of prehistoric "farmer's almanac," he was able to inform himself about seasonal changes, nearly to the day, and gauge the timing for all-important moves to fresh hunting or fishing locales.

Actually a problem in economic archaeology suggests itself here. It would be interesting to discover for certain if the possessors of the lunar notational system were indeed better nourished than the people without (the old story of the "haves" vs. the "have nots"). There logically had to be a forerunner to the calendrical systems of the higher civilizations, Marshack rightly reasoned. He objected to the vague notion that calendrical systems began "suddenly," and thus embarked upon a sideline research which diverted his attention (happily for prehistory) from finishing another book on space. The professional archaeologist may at first balk at the thought of a non-archaeologist telling him about his domain. But we must remember that it was a non-archaeologist who applied the study of dendrochronology to the prehistory of the American Southwest, and another non-archaeologist who gave us the carbon-14 method of dating.

One mild criticism: Nowhere in the book is there an illustration of the tool or burin (graver) which the prehistoric men used to make the cuts. Seemingly Marshack was so engrossed in portraying the mind of prehistoric man that he neglected the lowly tools his subject used to make the marks.

The Roots of Civilization merits serious study. It has already won just praise from leading Old World prehistorians, and we are looking forward to more publications from Marshack on this subject.

—Ralph S. Solecki
Anthropologist, author of *Shanidar*—
adapted in SMITHSONIAN, May 1971.

Grzimek's Animal Life Encyclopedia
Dr. Bernhard Grzimek, Editor-in-Chief
(Van Nostrand Reinhold, $29.95 each)

I have had the pleasure of inspecting Volumes 10 and 13 as well as a portion of Volume 7 of the projected English edition of Grzimek's *Tierleben,* and I think this ambitious undertaking is off to an excellent start. The text is authoritative, but easy to read. With a little help on technical words, my 11-year-old son could comprehend and enjoy it. Yet these are by no means children's books, but a set that even professional zoologists will find extremely useful.

These are profusely illustrated volumes. Pictures are mostly color—photographs and paintings that cover almost all genera.

The English edition is coming out five years after the German publication. Since our knowledge of the field is fast increasing, some lag inevitably shows up. This

is no criticism, but rather an expression of sympathy. Translations are mostly well done, though the quality of different sections varies with the capabilities of their particular authors. The editor tried to select leading experts in the field for authorship and in the main succeeded. But there is a bias toward Central European authorities.

Another volume is due this month and another in October. Completion (13 volumes) is scheduled for June 1974. If the present standard is maintained, the set will play a pivotal role in disseminating natural history throughout the English-speaking world.

I endorse this encyclopedia most enthusiastically to the professional and layman alike.

—John F. Eisenberg
Resident Scientist, Research Division,
National Zoological Park

The Late John Marquand
Stephen Birmingham
(Lippincott, $10)

John P. Marquand was the fabulist of "proper" Boston and has remained unrivaled for the role. Not that he was one of the Brahmins. Almost, but not quite. And his failure to reach that top rung of Boston Society, to make Harvard's Porcellian Club and all it stood for in 1915, dictated a theme that was to run through most of his stories—a man's struggle to achieve success and status without having been born to them.

John P. Marquand, sketched at the time of his first marriage, in 1922.

Virtually all of Marquand's books—*The Late George Apley, H. M. Pulham, Esquire, Wickford Point* and the others—mirrored his many frustrations. In them he vented his resentment against many of his relatives and reflected some of the strange contradictions in his personal life. He gained wealth, for example, yet grew parsimonious; he committed adultery, yet turned his affair into a pleasant *ménage à trois.*

Stephen Birmingham, respected chronicler of the rich, has here compiled a fascinating literary biography. In terse vignettes he captures the essence of Marquand's associates in those golden times (and onward), from Sinclair Lewis and George S. Kaufman to Edna Ferber and Mrs. August Belmont. He also describes one of the author's few happy experiences—his years as a judge for the Book-of-the-Month Club, where he proved to be a lusty and hilarious court jester.

Marquand emerges as a man whose achievements had a way of rising up and mocking him. Like his heroes, he was "always looking back, wondering where it all went wrong, what turn, if taken, might have changed the course of everything."

—Michael J. Bandler
Free-lance writer and book critic

I've Had It
Robert Hopkins
(Holt, Rinehart and Winston, $7.95)

So there you are, doing whatever it is you have to do to make a living and telling yourself that there's got to be something in life better than this. Or you're getting more and more fed up with welfare programs, the tax bite, Vietnam . . . or you're sick of commuting, the drug problem, violence . . . or you want to do something *meaningful.*

So you've got this dream that someday you'll start fresh somewhere else, teaching bright-eyed, sponge-minded kids in an African village or retiring on your pension to Ireland or Portugal, where your dollar still buys something. You may plan to make the scene in France or Italy, where society respects the artist in you, or be a pioneer on those frontiers in Canada or Australia, or take your bundle to Latin America.

Then you pick up a copy of Robert Hopkins' *I've Had It,* beguilingly subtitled, "A Practical Guide to Moving Abroad," and before you're halfway through the first few chapters you come to the dismal conclusion that a sub-subtitle might well read: "1,001 Reasons Why You Should Forget It."

I've Had It is an honest book. This does not necessarily mean that it is wholly accurate. But any book as full of bad news for the adventurous or the alienated must nestle close to the truth.

Consider: Most countries don't want you. Even those nations that are actively seeking immigrants (Australia, Canada, Israel, New Zealand, Rhodesia and South Africa) are less than interested if you don't have a critical skill or a private source of income with money to invest.

In many countries you won't be allowed to work at jobs or professions that can be handled by a national. Red tape often borders on the incredible and the time lag between applying for a resident's visa and getting the multitude of documents approved can sometimes send you slinking back to your own polluted briar patch. Also, if you have *hair,* cut it. Otherwise, many countries, especially in Asia and the Middle East, won't even let you near the gate.

If you do make it to the paradise of your dreams, you still face problems. Wages are low, unless you work for the U.S. government or a big American company—and such jobs are getting scarce. The cost of living is usually low for local goods, but high for the imports that Americans cherish. Apartments to rent are generally hard to find and the cost is sky-high. The culture shock, says Hopkins, can lead to "near-complete mental and physical debilitation."

If you're one of the 24 million Americans who claim to have had it, read this book before you take off.

—James A. Cox
New Jersey writer, only semi-alienated

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The Moths of America North of Mexico
Editors: Douglas C. Ferguson, John G. Franclemont, Ronald W. Hodges, Eugene G. Munroe, Richard B. Dominick, Charles R. Edwards (E. W. Classey & R.B.D. Publications, $39 for each study)

The second published part (fascicle 20.2A) of *The Moths of America North of Mexico* appeared last December and is now followed by the third published part (fascicle 20.2B) a continuation of the treatment of the giant silkworm moths and their relatives of this continent. These parts are representative of the proposed 30 fascicles that will comprise a work designed to illustrate all of the species of moths (estimated at more than 10,000). The six editors plan to give diagnostic characters of each species and genus, to discuss larval food plants and limited biological information and to give the known geographic range and flight period for each species.

The project is based on the great collections of North America, primarily those of the U.S. National Museum, the American Museum of Natural History, the Canadian National Collection and the personal collection of Dr. John G. Franclemont of Cornell University. These collections cover nearly completely the known fauna of North America, so that practically every species, geographical race or form is available to the board of editors.

Some biologists believe in the existence of subspecies, or geographical races; some don't. Dr. Douglas C. Ferguson, the author of fascicle 20 (parts 2A and 2B) does believe in them and presents a very convincing argument not only for the occurrence of subspecies in nature, but also for the mechanics of handling the application of the subspecific names. He draws into his discussion the use of "form" and "aberration" and gives a lucid explanation of the difference.

Under each species, distribution is given and extensions of ranges are discussed; variation, comparison with allied species, feeding habits and food plants are recorded.

Following the text on classification is an extensive bibliography, the color plates and an index. The color plates are superb. There are 22 of them depicting all the species and major variations. The plates alone are usually adequate for the identification of species.

These books are designed for the professional and amateur alike. Those who conceived this project—which will extend over a period of at least 12 years—are to be congratulated.

—*J. F. Gates Clarke*
Senior entomologist, Smithsonian Institution

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Individually designed tours of natural or historic areas of the United States and Canada emphasize educational experiences. Many offer working participation in the activities of the area and each one is led by an expert in the field. In addition, a Smithsonian representative travels with each group. The tours are limited in number according to the type of activity involved. For information: Mrs. Patricia Kilkenny, Room 106 SI, Smithsonian Institution, Washington, D.C. 20560.

Mountain Camping: Camping and hiking in Washington's Mount Adams wilderness—August 21-31.

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Instruction in Photography: Field experience in Maine, including landscape, mills, old farms and coastal areas—September 24-29.

Arizona Astronomy Weekend: Introduction to the Smithsonian's Mt. Hopkins Observatory and other research facilities in the Tucson area—October 6-9.

Blockade-Runners' View of the Carolinas: Coastal traverse, including visits to a shipwreck and maritime collections—October 21-27.

Sanibel Island, Florida: Exploration of a Gulf Coast barrier island and the wildlife refuge—November 5-10.

Nature's Past: Florida's West Coast from Sanibel Island to flood-plain valley of Myakka River through jungle and cypress swamp—November 12-19.

1973 Tours

The Mission Trail of California: History, art and architecture on the route followed by Franciscan and Jesuit missionaries—January.

Birds of North Carolina: Migratory bird populations will be viewed at the optimum time at Mattamuskeet Wildlife Refuge and Cape Hatteras—February.

Big Bend National Park: A visit to this contrast of buttes, desert areas, mountains and river chasms including a boat trip—March.

Medal Makers and Collections: Witness the growth of an idea for a medal through the stages of completion at the Franklin Mint, Philadelphia, with visits to private and public collections—March.

Family Weekend at the Smithsonian: Fossil collecting, mineral trips, tours of astronautic exhibits, and a review on how an exhibit is made are included in the weekend plans, designed and priced for family participation—April.

Musical Instrument Makers: Meet the makers of dulcimers, fiddles and zithers in Virginia and the Carolinas and study their skills—April.

Vanishing Indian Crafts: A tour designed by the Navahos to demonstrate their ancestral crafts and show what they are doing to keep them alive—May.

Family camping: An inexpensive learning experience for the family, stressing geology, birds, plant life and weather—June.

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International tours offer an unusual opportunity to study natural history, archaeology, the arts, museums and private collections with a scholar in the field of interest involved. They are scheduled throughout the world. A suggested reading list offers background information on each trip and on the lectures or seminars conducted during the tour. A Smithsonian representative also accompanies the group. Tours are generally limited to 30 members. For information: Miss Bliss Schumann, Room 123 SI, Smithsonian Institution, Washington, D.C. 20560.

"No Tour" Tour: Dulles International Airport to London and return—September 11-October 2.

The Pilgrimage Road: The route of medieval pilgrims from Paris through Burgundy and Bordeaux to Santiago de Compostela—September 11-October 9.

Russian Museum Tour: September 12-October 3. (waiting list only)

Pakistan and Afghanistan: October 9-November 8. (waiting list only)

Antique Tour of London: For buying as well as looking—November 2-10.

1973 Tours

Peru: Archaeological sites, folklore and anthropology (depart and return Miami)—February 8-March 3.

Morocco: Atlas Mountains, archaeological sites—March 6-27.

Cave Paintings: A tour of prehistoric caves of Spain and France—April 2-24.

Middle East: A trip through Syria, Jordan, Lebanon and Cyprus to see classical sites, crusader castles, Arab cultures (depart and return London)—April 13-May 4.

Baroque Tour: An emphasis on Baroque architecture in Germany, Austria and Switzerland—May 13-June 4.

African Safari: Tanzania and Kenya game parks, plus the Seychelles in the Indian Ocean—July 17-August 7.

Aerospace Museums: A two-week visit to these special museums in Munich, Geneva, Moscow and London—September 10-24.

Sites of Civilization: The cruise ship *Argonaut,* chartered for Smithsonian Associates, will travel from Athens to Rome via Thera, Crete, Egypt, Carthage, Malta and Sicily (depart and return New York)—starting October 6.

Smithsonian acquisition

Mgeni Mopaya's debut at the zoo

For weeks, volunteers from the Smithsonian's Friends of the National Zoo maintained a nightly pregnancy watch. Then on the morning of May 29, Femelle gave birth to her first baby, a son. Nikumba, the father, who did not join in the vigil (this is his fourth) had come from Zaire; the embassy of that African country named the five-pound ten-ounce infant "Mgeni Mopaya," meaning "guest host."

Smithsonian highlights

Summer hours now in effect at the Smithsonian are: 10 A.M. to 9 P.M. for A&I, MNH and MHT. Hours for the other buildings remain 10 A.M. to 5:30 P.M.

Smithsonian Building
"New England Textile Manufacturing" illustrates with artifacts and photographs the history and development of the textile industry and its related architecture during the 19th century. Included are: original samples of fabrics, patent models for mill machinery and an actual loom.

Renwick Gallery
"Announcing the Avant-Garde: Playbills by Post-Impressionists" includes some 75 19th-century programs created for the experimental Theatre Libre and Theatre de l'Oeuvre by Lautrec, Bonnard, Vuillard, Munch, Signac, Denis and others. Opens August 12.

"Franz Barwig," sponsored by the Austrian Institute, opens August 12 and features 21 works in bronze and wood by the Viennese sculptor.

Cooper-Hewitt
During reorganization at this New York City museum, a series of hour-long films on urban design is being projected on the fence surrounding the museum.

Museum of History and Technology
"Right to Vote," from colonial times up to the 26th Amendment, shows the nation's trend toward a more inclusive suffrage. Opens late August.

"Sculpture in Light and Motion" created by Adam Peiperl is art in physics, featured in the Physical Sciences Lounge.

Printing and Graphic Arts Hall with demonstration shops displays period rooms with printing presses and exhibits of printmaking techniques.

Money and Medals Hall has reopened its national coin collection and the Lilly gold coin display (see SMITHSONIAN, December 1970).

"Why Teeth" features Billy Bad Tooth and Molly Molar in a slide show with drawings and sculpture explaining why we have teeth.

Mutascopes, one with a Plexiglas side to reveal its inner workings, feature early Edison newsreels and naughty (c. 1905) flip-card shows.

Division of Performing Arts
"The Marvelous Land of Oz" puppets, until September 4. Performances are at 11 A.M., 12 and 1 P.M., Wednesday through Sunday. Call (202) 381-5395.

Freer Gallery of Art
"Recent Japanese Accessions" is a special exhibit in honor of the Japanese-American Citizens League.

Arts and Industries
"Space Art" includes 70 paintings on space and astronomical art.

National Portrait Gallery
"If Elected . . ." features portraits and campaign memorabilia of men and women who ran for the Presidency and lost and includes audio tapes of speeches by such also-rans as William Jennings Bryan (see June SMITHSONIAN). Four documentaries, three on past candidates and one entitled "The Women Get the Vote," are shown at 11:30 A.M. and 1:30 P.M., Monday through Sunday.

National Collection of Fine Arts
"Artist-Naturalists: Observations in the Americas" features prints, drawings and watercolors by Audubon, Mark Catsby and other artist-naturalists.

"National Community Arts Competition" includes original work and photographs representing the winners of HUD's competition for new ideas in environmental decoration.

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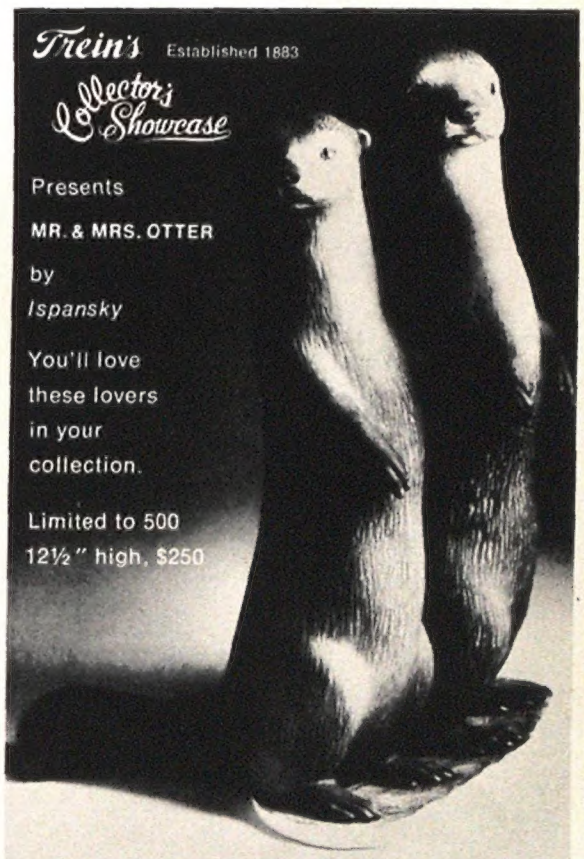

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Museum of Natural History
"The Shadow of a Stone-Age Man" sheds light on a culture 30,000 years old, with unique soil shadow (three-dimensional body cast) of paleolithic hunter found in northern Spain and grave offerings with which he was buried.

"Insect Zoo" contains a wide variety of living insects (including a termite colony, beehive, ant mound) and uses audio-visual aids to show some of the remarkable biological features of common and rare insects. Nearly all aspects of an insect's life history will be illustrated.

"Botanical Sculptures in Gold, Silver and Minerals" features sculptures composed of lost-wax castings in precious metals with minerals and gems.

Smithsonian Commons
Luncheon facilities for members of the Smithsonian Associates are located in the original Smithsonian Building. Open weekdays from 11:30 A.M. to 2 P.M., the Commons offers a buffet luncheon from $1.40 to $1.85 upon presentation of a membership card.

Traveling Exhibition Service
There are up to 70 different Smithsonian-sponsored exhibitions on display each month throughout the United States and Canada. For a complete listing and information on how to bring an exhibit to your area write: Traveling Exhibition Service, Smithsonian Institution, Washington, D.C. 20560.

- Columbus, Ohio—"Movie Palace Modern" (Huntington Gallery, August 5-September 3).
- Tucson, Ariz.—"U.S. World War I Posters" (University of Arizona, August 19-September 17).
- Edmonton, Alberta, Canada—"A Children's World II" (The Edmonton Art Gallery, August 5-September 3).
- Anchorage, Alaska—"Vanishing Totem Poles" (Anchorage Historical & Fine Arts Museum, August 5-September 3).
- Jamestown, N.Y.—"Indian Images I" (James Prendergast Library Association, August 19-September 17).
- Midland, Tex.—"Photographs of a New Guinea People" (Museum of the Southwest, August 19-September 17).

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By David E. H. Jones

Would wide-angle specs produce superkid?

"Yes, I have a pair of eyes," said Sam, "and that's just it. If they wos a pair o' patent double million magnifyin' gas microscopes of hextra power, p'haps I might...see through a flight o' stairs and a deal door; but bein' only eyes you see, my wision's limited."

Thus does Sam Weller in *Pickwick Papers* defend himself in the witness-box. His lament for human optical equipment was probably echoed fervently by the purveyors of Victorian gas microscopes; and even today the scientific fraternity regards the windows of the soul as sadly irregular instruments. For resolution they are quite acceptable, being some 30 percent as sharp as they might be, but for breadth of vision they are simply deplorable. Their area of sharp focus would just cover a thumbnail at arm's length. To read this page you must track a tiny area of distinct vision along the print, then snap it back to the next line and start all over again. Don't you envy the camera which can register the whole page in fine focus simultaneously?

Of course your brain does its best to gloss over the deficiencies of its sensory servants. By swiveling the eyes around, focusing in quick succession on various bits of the available view, it contrives to maintain the illusion of a completely detailed picture, instead of a tiny sharp area surrounded by varying degrees of fuzz. It even manages to conceal the fact that one sector of the visual field, big enough to encompass nearly 200 full moons in square array, is completely blank. This blind spot on the retina is where the optic nerve joins the eye. Rather than leaving it as a black hole always lurking menacingly to one side of your field of view, the brain fills it hopefully with whatever colored vagueness seems to blend best with the surrounding scene. So successful is all this optical illusioneering that only by stringent testing—as when you hold your eye rigidly fixed and discover just how little of the page you can see really well—is the outrageous fraud exposed.

Curiously enough, astronomical telescopes, those mightiest triumphs of the optical industry, share with the humble eye this defect of restricted gaze. The big mirror of Palomar, 200 inches across, has much narrower angle of distinct vision even than your eye, though within its limited compass it is a million times as penetrating. More intriguing still, the narrow view of some big telescopes has been widened by fitting them with "glasses." The Schmidt corrector-plate, named for its inventor Bernhard Schmidt who made the first model in 1931, is a carefully figured disk of glass, placed a precise distance in front of the mirror. There it distorts wide-angle light in exactly the opposite way to the big mirror itself. The two distortions cancel out and a splendid wide-angle picture results.

The Schmidt telescope is the finest wide-angle information-collector known to astronomers, and so it is natural to speculate whether our own narrow view of things could similarly be widened by Schmidt-corrector spectacles. Then we would view the world in genuine panoramic sharp focus like a camera, and save the brain its ceaseless patching and conjuring. It would be far better employed deciphering the big picture, so that you could understand this page in a glance.

It is, of course, too late for us oldsters. We would simply be bewildered by a world delineated in remorseless detail, horizon to horizon, and would long again for our old narrow vision that singled out just one face or figure at a time for our feeble comprehension. Only our children, brought up in Schmidt spectacles as the natural way of seeing, could enter into the new optical heritage and, with computerlike grasp of boundless detail, revel in a new and widened world.

But maybe after all it is not such a good idea. The generation gap already yawns vast enough without the superfluous addition of sensory differences. And in a world made garish by TV barons and admen, perhaps the ability not to see 99.995 percent of what is in front of our noses is blessed indeed. Instead, perhaps we should be glad that a merciful providence has equipped us with such limited vision.

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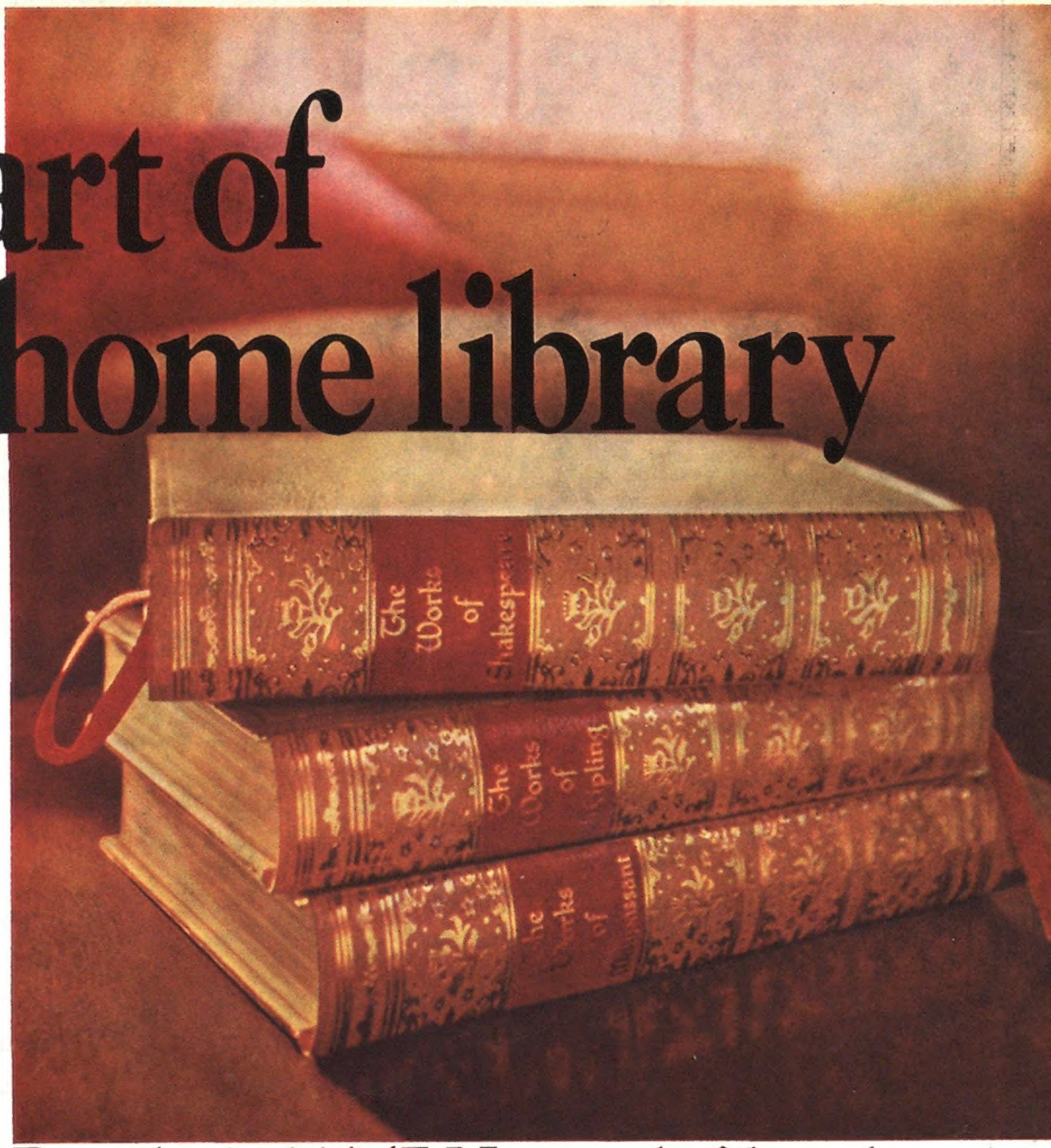

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